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Symposium on Policies for Economic Rationalization of Commercial Fisheries

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Introduction to the Symposium on Managing Fishing Effort

PETER H. PEARSE

Department of Economics, University of British Columbia, Vancouver, B.C. V6T 1W5

When economists began, in the 1950s, to discuss measures for improving the economic performance of commercial fisheries, the questions they asked themselves were academic. Then, even the most sophisticated resource management agencies confined themselves to regulation of stocks and yields, and propositions such as restrictions on access or royalties on landings could be debated in the relaxed scholastic atmosphere that goes with confidence in their irrelevancy to decision-making in the real world. But that was 20 years ago.

Since then, the literature on this subject has expanded exponentially, and fishery economics has assumed a vigorous life of its own inside and outside academe. Nevertheless, it is safe to assert that no one predicted the demands that policy-makers would suddenly put on our limited understanding of techniques for rationalizing primary fishing industries. Today, fishing nations around the world are searching for policy instruments to improve their fishery economies and the incomes of fishermen.

The urgency of this search was precipitated by the vast extensions of fisheries jurisdiction by coastal states during the last couple of years, which imposes on them new responsibilities for resource management and for regulating domestic and foreign fishing. A related factor (because it was the alleged justification for extending jurisdiction) has been the alarming decline of many of the world's most valuable fish stocks, the result of increased harvesting pressure as fish prices have risen and fishing technology advanced. Important, too, has been the influence of continuing research by fishery economists in generating widespread appreciation, particularly in North America, of the need for public intervention not only to protect the natural resources, but also to prevent the perversities of common-property fishing from dissipating the potential economic value of the harvests.

A crisis, properly defined, is a state of affairs in which a decisive change for better or worse is imminent, and in this sense there is now a crisis in fisheries policy. A recent official statement of Canada's fisheries policy includes, for the first time, the objective of economic efficiency in industrial organization (Fisheries and Marine Service 1976). Toward this end, the tradition of free access has been swept away during the last couple of years and all important commercial fisheries in this country

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have been subjected to restrictive licensing. The United States, Australia, Japan, and a few other countries have introduced similar measures that portend profound, but still uncertain, changes in the development of fishing industries.

While fisheries authorities have begun to understand the special case for economic regulation of fishing and to appreciate what has to be accomplished, there remains great uneasiness about the best way to proceed. Only a handful of rationalization programs have been in place long enough to provide case studies with revealing documentation, and the measures that are to follow the initial licensing restrictions in other fisheries remain to be decided. As a result, governmental policy-makers are putting heavy strain on inferences from our meagre experience and inductive research.

These circumstances have drawn public administrators and economists together in renewed interest in fishery regulation, and the symposium at which the papers in this volume were presented was conceived as a timely vehicle for pursuing this common interest. Jointly sponsored by the Fisheries and Marine Service of Canada and the University of British Columbia's Programme in Natural Resource Economics, the whole activity was organized by a Steering Committee consisting of James Crutchfield, Lloyd Dickie, William MacKenzie, Fred Popper, and me.

The symposium was designed to bring together a small number (about 30) of leading fishery economists and fishery administrators with experience in this field from Canada, the United States, and elsewhere. Our purpose was to pool our knowledge about the current state of the art in economic rationalization of fisheries, to document and analyze the available experience, and to explore avenues of needed policy research. Drafts of the papers were circulated well in advance, and the revised versions that appear here have benefited from 5 days of lively commentary and debate at a retreat in Powell River, B.C., in August 1978.

We began from the position that governments seek to improve the economic performance of fisheries (readers of this volume will therefore find scant discussion of the old arguments in justification of economic regulation in the first place, which occupy so much space in the literature). Our attention was focused on methods. For this reason we were concerned less with theoretical analysis than with analysis of policy alternatives (although of course the latter builds on the former). We sought to illuminate the implications of alternative institutional arrangements for regulating fisheries, and the efficacy of licensing, fiscal, and other devices in promoting social objectives.

The papers collected here are grouped into three parts. The first deals with general developments in fisheries regulation policy and relevant economic theory. A. W. H. Needler draws on his extensive experience in Canadian and international fisheries administration to trace the evolution of fisheries policy in Canada, from its early preoccupation with conservation and marketing to recent concern for the industry's economic organization and performance. Anthony Scott, in a perceptive analytical review of the literature on fishery economics, identifies its limited progress in the basic theory of regulation, and the apparent divergence between economists' concern for efficiency on the one hand and the distributive goals of policy-makers on the other. James Crutchfield's paper examines the main approaches to control of fishing effort that have been taken or advocated and concludes that some combination of input restrictions, levies on the catch, and quantitative rights is more promising than any single measure.

Crutchfield tends to favor vessel licensing supplemented with substantial royalties or taxes on landings. This contrasts with Scott's advocation of a system based on transferrable fisherman quotas, and the arguments of these two authors thus focus attention on one of the most important and interesting debates in economic regulation. It will be noted that their differences are based not so much in theory as on administrative practicality, acceptability, flexibility, and consistency with distributional objectives.

The five papers of Part II describe and evaluate four of the most interesting and revealing attempts at economic rationalization so far. Alex Fraser reviews the 10-year history of Canada's west coast salmon fleet control program and, like

Crutchfield, concludes that it has failed to check the growth of redundant fishing capacity because the gains from rising fish prices were left in the hands of fishermen to invest in vessels and gear. Analyzing the available data, James Wilen and I find that while capital expansion appears to have been slowed somewhat under the program, there is no convincing evidence that the controls are adequate to ensure that potential resource rents will be realized.

The much more complicated limited entry program embracing all of Alaska's fisheries is reviewed in papers by Alan Adasiak and George Rogers. While experience with this Alaskan program is too short to afford much assessment of its success in controlling fishing effort, these papers document an interesting case study in introducing, administering, and enforcing a comprehensive regime of entry restriction in a complex social environment. Finally, Frank Meany examines experience with limited entry in two of Australia's important fisheries; he attributes much of the apparent success in the Western Australian prawn fishery (in contrast to the rock lobster fishery) to monopolistic elements in its industrial organization.

Part III consists of four papers, each of which analyzes a particular kind of adjustment problem in managing fishing effort. Woldzimierz Kaczynski analyzes the difficult position of distant-water fishing nations, especially those of the socialist bloc, resulting from extended coastal jurisdiction and consequent regulation by coastal states. W. C. MacKenzie examines Canada's Atlantic groundfisheries, as a case study in the problem of attempting economic rationalization in a region characterized by low incomes, unemployment, part-time dependence on fishing, and labor force immobility. He also cautions against exaggerated predictions of economic resurgence as a result of extended fisheries jurisdiction. Dennis Cauvin shows how computer simulations can be used to demonstrate the expected evolution of an inland fishery under alternative fleet control policies. He goes on to argue that probably the major impediment to the implementation of rational fishery policies is the bureaucratic environment in which fishery managers must work.

The final group of papers, in Part IV, covers disparate problems. In a provocative essay on the development of conventional wisdom in fishery biology, Lloyd Dickie questions some of the accepted concepts in resource analysis (such as that of "stocks") and suggests new approaches that may be more appropriate in the complex situations that will increasingly be encountered. Daniel Huppert analyzes the economic implications of two common but relatively unexplored problems in fisheries regulation, namely the harvesting of mixed stocks and the efficient use of multipurpose fleets. James Wilen investigates the investment behavior of fishermen and explains why there will be a continuing tendancy toward overcapitalization even when restrictions are put one one or a few inputs, as long as the technology of fishing is flexible. In the final paper, David Moloney and I describe how the relatively novel idea of quantitative rights, or "stinting," might be introduced in fisheries, and why it could be expected to encourage efficient industrial organization.

The last paper, and the one by Lloyd Dickie, were not presented at the symposium itself but were written as a result of discussions at our round-table sessions. On the other hand, some of the papers presented are not included here for various reasons, though it must be acknowledged that we, and the papers published herein, benefited from them. Most of the papers in this volume were revised by the authors following the symposium, all were submitted for external evaluation, and each was then revised again in light of the referees' comments.

It is notable that many of the important contributions to fishery economics appear in the form of proceedings of international conferences, such as those sponsored by the FAO in Ottawa in 1956 and in Rome in 1961, and by the OECD in Paris in 1972 (Turvey and Wiseman 1957; Hamlisch 1962; OECD 1972). It is testimony to the short history of this subdiscipline that the names of some of the contributors to the earliest of these appear in this collection as well. Those of us who attended this symposium feel we participated in another incremental advance in our understanding of the problems of fishery regulation, and we hope that by means of this volume we can share with others at least some of that stimulating experience.

FISHERIES AND MARINE SERVICE. 1976. Policy for Canada's commercial fisheries. Department of the Environment. Ottawa, Ont. 70 p.

HAMLISCH, R. [ed.]. 1962. Economic effects of fishery regulation. Food and Agriculture Organization of the United Nations, Rome.

OECD 1972. Economic aspects of fish production. Organization for Economic Cooperation and Development. Paris 480 p.

TURVEY, R., AND J. WISEMAN [ed.]. 1957. The economics of fisheries. Food and Agriculture Organization of the United Nations, Rome. 234 p.

Symposium on Policies for Economic Rationalization of Commercial Fisheries

PART I

Developments in Policy and Theory

Evolution of Canadian Fisheries Management Towards Economic Rationalization[1]

A. W. H. NEEDLER

Huntsman Marine Laboratory, St. Andrews, N.B. E0G 2X0

NEEDLER, A. W. H. 1979. Evolution of Canadian fisheries management towards economic rationalization. J. Fish. Res. Board Can. 36: 716–724.

The evolution of the regulation of fisheries in Canada is outlined as background for a discussion of their economic rationalization through restriction of entry. The objectives of fishery regulation are discussed and questions noted that must be answered if limitation of entry is to be beneficial and acceptable.

Key words: regulation, rationalization, management, limitation of entry

NEEDLER, A. W. H. 1979. Evolution of Canadian fisheries management towards economic rationalization. J. Fish. Res. Board Can. 36: 716–724.

L'auteur esquisse l'évolution du contrôle des pêches au Canada comme toile de fond à une analyse de leur rationalisation économique par le biais de la limitation de l'entrée. Il examine les objectifs du contrôle des pêches et attire l'attention sur les questions auxquelles il faudra trouver réponse si l'on veut que la limitation de l'entrée soit avantageuse et acceptable.

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1. It is an honor and a challenge for a biologist–administrator to be asked to present the introductory paper for "a symposium on policies for economic rationalization of commercial fisheries" dominated, quite properly, by professional economists. The function of this paper is not to deal in depth with the economic theory and practice now being brought to bear more and more on the commercial fisheries, especially on the question of control of entry; the function is, rather, to give an historical review of the development of fisheries management in Canada as background for an understanding of the increasing need and improving opportunity for economic rationalization. Recent steps in that direction will be examined in later papers in this symposium but neither their purpose nor the problems they meet can be well understood without some attention to the historical background of fisheries management in Canada.

2. This is indeed an opportune time for a consideration of entry control in commercial fisheries — its role and objectives and the problems associated with its application. In this century, and especially in the last few decades since World War II, major changes have taken place in fisheries the world over, and not least in Canada. This dynamic situation demands constant watchfulness in order to adapt management to new problems and to the changing emphasis on the various aspects of what has always been its objective: to obtain from exploitation of the resource the greatest possible benefits to society as a whole and, more particularly, to assure the economic welfare of fishermen and fishing communities, including the fish processing industry and the fish trade.

3. A review of all fisheries management in Canada would be so fraught with detail that both reader and author would be hopelessly confused. In this background paper I have drawn on personal experience and close contacts with management for about half a century and have tried to keep the statement brief and readable by avoiding detailed documentation. It is hoped that the resulting generalizations, though oversimplified and open to question, may be usefully thought-provoking.

Confederation to World War II

4. *Early Canadian fishery management* — The Fisheries Act was one of the earliest pieces of legislation by the Canadian Parliament. The British North America Act had given the central government responsibility for the regulation and protection of fisheries, being apparently influenced by the view that neither the fish nor the waters in which they live nor fisheries problems are respecters of political boundaries. The Fisheries Act set forth broad and strong powers of regulation relating to the catching of "fish" (defined to include all living aquatic resources) and the protection of their environment from pollution and obstructions. A pat-

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[1] This paper forms part of the Proceedings of the Symposium on Policies for Economic Rationalization of Commercial Fisheries held at Powell River, B.C., August 1978.

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tern soon developed of publishing regulations for each province and some on special subjects (e.g. the lobster fishery) in more than one province. The regulations were passed by Order-in-Council, frequently changed, and sometimes concerned petty details (e.g. prohibiting fishing within a few hundred feet of a particular bridge!). They did, however, try with some success to bring order to fishing and prevent abuses.

5. *Early concern for conservation* — The principal purpose of early fisheries regulations was to protect the fish stocks from overfishing and depletion. Attention was concentrated on those stocks where the danger appeared to be greatest — the fish and shellfish caught close to shore and the freshwater and anadromous species. Indeed there were no restrictions at all on the great Atlantic fisheries for cod and other "groundfish" until the 1940s (except for limiting the number of trawlers in the 1920s and 1930s in answer to strong pressure from hook-and-line fishermen).

6. The regulations themselves were based on popular concepts — protect the young and don't interfere with reproduction. Common measures included minimum sizes of fish to be caught and retained (also of some significance to marketing), minimum sizes for meshes of gill nets and trap nets, prohibition of retaining female lobsters carrying fertilized eggs ("berried lobsters"), prohibitions of catching certain species during spawning seasons or on spawning grounds, etc. The measures were not always well based but were well-intentioned attempts, and all that was possible in the absence of an adequate scientific basis.

7. *Economic aspects of early fisheries regulation* — Some regulations were related more to *marketing* than to conservation. For example, an important factor in determining lobster fishing seasons was avoidance of moulting with its consequent poor quality; another was avoidance of times when Canadian live lobsters, sold mainly in USA, would compete with Maine lobsters with consequent danger of lower prices and of tariff barriers. In fact, closed seasons for lobster fishing, though popularly regarded as conservation measures, had no such effect, the highest proportion caught annually (about 75–80%) being in a district with a very short season. Many other examples could be cited, especially perhaps in the Pacific salmon fishery, of the inadequacy, as a conservation measure, of limiting the time for fishing without at the same time limiting the amount of fishing (number or effectiveness of fishing units). There are also many other examples of considerations of quality or of marketing influencing closed seasons for fishing.

8. There was no attempt to limit entry to fisheries or the amount of fishing, either for conservation or economic purposes. It seems that the idea of limiting the numbers of fishermen or fishing units did not emerge in the thinking of those concerned with fisheries management until the 1940s; the first major attempts to apply the concepts did not come until the 1960s. In early regulation licensing was not used to limit entry, to deter entry (fees were usually ridiculously low), or seriously to raise revenue; licensing was used to identify fishermen as an aid to enforcement (licenses can be canceled) and, somewhat improperly from the point of view of jurisprudence, for regulation through the terms of licenses.

9. *Early faith in hatcheries* — An interesting phenomenon of the late 19th and early 20th centuries in North America was unjustified faith in the efficacy of fish hatcheries to maintain or increase the stocks of commercial fishes. Hatcheries were even used in New England to hatch the eggs of cod and other sea fishes and release small fry. In Canada we had numerous lobster hatcheries until it was shown in the 1920s that the female lobster did a much better job than the hatchery jar. When an arduous scientific study indicated that the sockeye salmon hatchery at Cultus Lake, B.C., did not pay, the reaction of the Department of Fisheries was to close all the B.C. salmon hatcheries. Thus the pendulum swung too far the other way and actually created difficulties in obtaining support for more scientifically based fish culture projects on salmon and other species. Luckily the pendulum has swung again and new promising attempts to increase production of commercial species by artificial means are receiving the support they deserve. The subject is mentioned here because I believe the faith in the simple hatchery process contributed to a too-complacent attitude to some instances of over-fishing in the early days and may have delayed the advent of sound fisheries management. There is need both for man-made improvements and for regulation of fishing.

10. *Developing the scientific background for fisheries management* — In 1898 on the Atlantic coast and in 1908 on the Pacific the first marine biological stations operated by the Canadian government were established. They depended at first mainly on seasonal research by university scientists but developed year-round scientific staffs in the 1920s and 1930s. From the beginning these institutions made valuable contributions to the scientific background for management through studies of life histories, distributions, migrations, stocks of important species, and their relations to biological and physicochemical oceanography or limnology. In the 1920s and 1930s more and more attention was given to particular fisheries management problems. It is my impression that in the early 1940s there was at last a turning point in attitudes of government and industry from mild interest, tempered with scepticism, to a demand by both administration and industry for more research than funds would permit. Scientists of the Fisheries Research Board played a major part in the development of fisheries regulation on both coasts. They are now so involved that one might fear that the pressure for applied science in the form of scientific advice on management may, with limited funds, allow too little attention to be given to true research in this

field, i.e. the development of new ideas and principles rather than application of old. Be that as it may, the scientific basis for regulation of fisheries has made great strides since World War II.

The Postwar Explosion

11. *The postwar expansion of fisheries* — The industrial and technological revolution was slow to affect fisheries. Although the steel, steam-powered fishing vessel and the otter trawl had made their appearance before the turn of the century, and although some overfishing took place between the World Wars in restricted areas of the high seas (e.g. the North Sea), the full impact of the technological revolution was not felt until after World War II. It affected fisheries both directly and indirectly. It made the fishing activity itself more effective (not necessarily more profitable) with such equipment as powerful long-range vessels with processing and storage facilities, fish-finding instruments, depth-controllable midwater trawls, etc. It so improved processing, storage, and transportation of fish products as to expand world consumption and it thus brought about a great increase in fishing. Increased fishing power of distanct-water fleets was largely responsible for an increase in the world's annual take from about 20 million t in the early postwar years to about 70 million, at which it now seems to be starting to level off. This great increase in fishing power and in catch was associated, as is typical for fisheries, with gross overcapitalization and with the advent of widespread overfishing in the true sense — a state of affairs where more fish would, in the long run, be caught by fishing less.

12. This "fishing explosion" and its dire impact on the livelihood of local fishing communities brought far-reaching effects. Governments reacted by extensions of jurisdiction to protect their coastal fisheries. Biologists and administrators reacted by recognition of the need for more effective regulation of fishing to maintain or restore yields. International cooperation in the management of fisheries was developed and strengthened. As a result a new regime is emerging which bids fair to stabilize fisheries at closer to their optimum yields than in earlier times. The stage is being set for taking economic factors into account with less danger from unbridled competition. In short, out of chaos, and sometimes disaster, is coming promise of good.

13. It seems well to take a brief look at what happened in the Northwest Atlantic where the International Commission for the Northwest Atlantic Fisheries (ICNAF) played an important role in the development of a new regime and where the sea fisheries have passed through the stages of expansion, overfishing, development of more effective regulation, and extension of jurisdiction, to recovery and the establishment of a new pattern of fishery regulation. It will then be profitable to take a look at the very different picture presented by the Pacific salmon — the only major fishery depending on anadromous species and therefore requiring a very different pattern of regulation. Both patterns have demonstrated some success; both have need and opportunity for economic rationalization.

Development of Regulation by Catch Quotas in the Northwest Atlantic Sea Fisheries

14. *The establishment of ICNAF* — Negotiated in 1949 and in force in 1951, ICNAF was established because of concern on the parts of Canada and the United States regarding the future management of the fisheries off their Atlantic coasts. The original membership included all the nations then taking part in those fisheries; in addition to Canada and the United States there were France, Portugal, Spain, Italy, Denmark, Norway, Iceland and the United Kingdom. The Commission had a small but effective permanent secretariat with headquarters in Canada. A very important feature was a standing committee on research which brought about close cooperation between scientists of the member countries, lasting to this day. In the early days of ICNAF reliance was placed on "qualitative" conservation measures such as size limits for fish retained or minimum mesh sizes in trawls. Although the Convention itself stressed the importance of the groundfish, ICNAF, as the need arose, extended its attention to other species of fish (e.g. herring, mackerel, silver hake, argentines), shellfish (e.g. scallops, squid, shrimps), and marine mammals (seals).

15. *The fishing explosion and the advent of serious overfishing* — In the 1950s and 1960s there was a massive increase in fishing by distant-water fleets for both demersal and pelagic fish in the ICNAF area. New arrivals in the fishery joined ICNAF (USSR, Poland, West Germany, Japan, East Germany, Bulgaria, Romania, Cuba) but until regulation by catch quota was effected in the early 1970s there was no limit on the amount of fishing or of catch. The effects on the fishery were drastic. Real overfishing became the order of the day. There were cases of concentrated fishing on certain stocks decimating year-classes at sizes far below those giving maximum poundage. The great complex of cod stocks off the east coast of Newfoundland and Labrador from which inshore fishermen had customarily caught over 150 000 t was so reduced that with about the same fishing effort they caught about a fifth of their former catches. This is only one example of many cases. Fishermen's feelings of frustration and resentment are readily understood.

16. *Introduction of regulation by catch quotas* — In the early 1960s it was realized that quantitative regulation of fishing, such as quotas on catch or effort would be necessary. In "yield-per-recruit" management (attempting to get the best poundage from a given number of small fish entering the fishery) it is necessary to keep the fish mortality caused by fishing in the rela-

tion to fish growth which achieves that end. ICNAF chose to control fishing mortality through catch quotas, deeming direct control of fishing effort too difficult to apply in fisheries employing a great variety of fishing equipment and fishing procedures, i.e. in most international fisheries. It was quickly agreed that if a total allowable catch ("TAC") is established for a fish stock, each country taking part in the fishery must have a separate national allocation; otherwise there would be a mad rush, with each country trying to maximize its share, leading to chaos and inefficiency in all stages of the fishery from catching to marketing. Delay resulted from the need to amend the Convention to give ICNAF a broad enough mandate to recommend national quotas but ICNAF moved quickly after receiving the authority in December 1971. Within 6 weeks TACs and national allocations were established for three major herring stocks, within 6 months a score of groundfish stocks were added, and a year later similar action was extended to most of the major stocks supporting international fisheries in the ICNAF area. This constituted a major ICNAF accomplishment and a first in international fisheries management.

17. Thus was born the regime under which each year TACs and national allocations are set for the succeeding year. ICNAF had reasonably good success in separating the setting of TACs on a scientific basis from the determination of national allocations which is mainly a political process.

18. *Setting TACs below "m.s.y." level* — Experience in ICNAF soon showed that limiting the catch from each major stock to the "maximum sustainable yield," or rather to a TAC recalculated each year at the "m.s.y." level using accepted methods, was inadequate to arrest overfishing. It continued until ICNAF, on the advice of its scientists, commenced in 1975 and 1976 setting TACs well below that level. This practice has now arrested overfishing and is leading to the recovery of badly depressed stocks. There are also economic effects. The lowered TAC means lower fishing intensity and, in the long run, lower costs; it can mean a lower catch but a higher financial return. In its most recent years the ICNAF scientists were asked to give their advice in the form of predictions of the effects of various levels of fishing on catch and on stock size over the next few years. On this basis TACs could be set taking into account economic as well as biological factors.

19. *Concern for spawning stocks* — The advent of severe overfishing shifted the attention of ICNAF scientists from reliance entirely on "yield-per-recruit" management to concern for the adequacy of some spawning stocks. The very large numbers of eggs in most commercial marine species, coupled with the failure of attempts to find valid correlations between sizes of broods and of the spawning stocks that produced them, had focused attention on "yield-per-recruit" management. In recent years, however, action has sometimes been taken to close fisheries when the spawning stocks had been very severely reduced, or to restrict fishing to assure the survival of an adult stock of a specified size estimated, on unavoidably shaky grounds, to be adequate. This concern for spawning stocks may become less important when stocks recover and more older fish are present again.

20. *Extension of jurisdiction over fisheries* — The culmination of many years of international discussions and unilateral actions is a world majority opinion supporting a 200-mile zone in which the coastal states have "sovereign jurisdiction" over resources including fisheries. Although the authority for this jurisdiction is not incorporated in an accepted Convention, it is in the draft text now emerging from the United Nations Conference on the Law of the Sea. Over half of the world's coastal states have established their 200-mile zones unilaterally, including most of the major fishing countries. The right to extend jurisdiction over fisheries to 200 miles has thus acquired the status of customary international law. Within its zone the coastal state has rights that include regulation of the fisheries, wide licensing powers, and as large a share of the yield as it can use; it has obligations that include maintenance of the living resources, and assurance of their optimum utilization by permitting other states to take that part of the sustainable yield not used by the coastal state.

21. Canada extended its jurisdiction over fisheries to 200 miles effective January 1, 1977. Although ICNAF had accorded the coastal states a large measure of preference in the size of their national allocations, Canada's extension of jurisdiction brought substantial further benefits. The Canadian share of the yield from fisheries within 200 miles is assured without argument; in some stocks fully used by Canada foreign fishing has been eliminated. Control of foreign fishing effort and enforcement generally have been greatly improved through Canadian licensing. Problems remain with respect to stocks that are partly within and partly outside the new jurisdiction; to date, however, Canadian recommendations on sharing the catch have prevailed. It is now Canada's responsibility to decide on equitable arrangements for continued foreign participation in fisheries for stocks inside 200 miles which Canaad does not use fully and this involves serious discussions and decisions.

22. *New Northwest Atlantic Fisheries Organization (NAFO)* — A Convention that came into force January 1, 1979 establishes the new Northwest Atlantic Fisheries Organization which will replace ICNAF. The Convention takes into account extensions of jurisdiction by all the coastal states of the area, which remains substantially the same as that of ICNAF. The new organization comprises a regulatory body ("Commission") to manage fisheries outside national jurisdictions, in much the same way as ICNAF, and a Scientific Council which advises the Commission on the basis for

regulatory measures and any coastal state, at its request, with respect to stocks subject to international fishing inside its zone. It is hoped that under NAFO the extremely valuable cooperation between countries fishing in the Northwest Atlantic, which developed under ICNAF, will be continued.

23. *The new background for fisheries management* — The experience in ICNAF has brought about a general appreciation of the facts that the immensely increased fishing power since World War II can quite quickly overfish almost any stock on which fishing in the Northwest Atlantic depends, that there is a limit to the quantity of fish that can safely be taken from each stock and that a properly managed system of catch or effort regulation can control overfishing and, indeed, bring about the recovery of depleted stocks. A workable regime of quota regulation has been developed. The companion development of extension of jurisdiction has placed the management of most stocks in the control of the coastal states. They now have the challenge of regulating the fishery to get the greatest value out of a limited yield, and they can make this attempt for the first time without the ever-present fear of excessive foreign fishing pressure. Indeed there is a new background for regulation for economic objectives.

Regulation of the Pacific Salmon Fisheries

24. Fisheries for salmon of the North Pacific from California to Japan together constitute the only major world fishery dependent on anadromous fish and present very different problems from those considered in the preceding section.

25. *Importance of "stock–recruitment" management* — In general the individual salmon has many fewer eggs than the marine species we have been discussing and perhaps this is not unrelated to the fact that whereas correlations between numbers of spawners and the size of the resulting broods are difficult or impossible to find in the latter, there is a recognizable relationship between the number of spawning salmon and the abundance of the next generation. Furthermore, salmon are so easy to catch as they enter their spawning rivers that without severe restriction of the fishery the salmon runs would soon disappear. These two characteristics make the "stock–recruitment" relationship the essential basis for regulation of the fishery to maintain the runs. By correlation of the sizes of successive spawnings with the sizes of the runs in the next generation an estimate is made of the number of spawners that on the average will produce the most progeny. The fishery is then restricted on a day-to-day basis to let the right number through to spawn (there can be too many as well as too few). To accomplish this requires (1) a long accumulation of data relating the size of the run to the day-to-day catch per effort, (2) intensive and quick collection, reporting, and analysis of information on catch-per-effort as the run proceeds, and (3) authority to close the fishery on short notice if not enough spawners are escaping the fishery. A highly developed organization and procedure carrying out such regulation now exists and is responsible for the relatively healthy state of most British Columbia runs. There are, however, many difficulties and complexities, a few of which are noted below.

26. *Desirable to manage individual runs separately* — The "run" of salmon of any one of the five species to any one of the hundreds of spawning streams is subject to its own special environment; it is adapted to that environment and returns to it at a time when it will ordinarily find suitable conditions for spawning and for survival of the eggs and young. The salmon runs in any one year are at various levels of abundance: low, high, or average. The more it is possible to manage the runs separately the better the scheme of management described in the preceding paragraph will work. It is commonly possible to give such individual attention only to the major runs. Even in their case it is often impossible to catch them separately because they mingle in the sea, and it becomes necessary to work out the most productive compromise between the somewhat different fishing regimes that would maximize the runs if they could be handled separately. In general, it would be best to avoid fishing mixed stocks as much as possible and this involves avoiding fishing runs at a distance from their home streams or on the high seas. Luckily it is probable that the Convention that emerges from the United Nations Conference on the Law of the Sea will prohibit the catching of salmon on the high seas outside national jurisdictions except under unusual circumstances that would not much affect British Columbia salmon. It is hoped that states can cooperate in regulating fishing for salmon runs that move between different zones of jurisdiction.

27. *Accurate prediction of the size of salmon runs not yet possible* — Although it is possible to make reasonably good estimates of the size of a spawning run and of the number of eggs deposited in the gravel, there is great variability in the proportion surviving to return as adults in the next generation. Their fate in freshwater can be observed — survival in the gravel to hatching and even to downstream migrations of fry or smolts to the sea — but no effective quantitative sampling has yet been devised to follow their early survival in the sea, and this varies considerably. Thus the size of run that returns from the sea is not yet predictable at all accurately; when and where the run will occur is relatively well known but not how many adult salmon there will be or, consequently, how many can be taken by the fishery and still leave enough to spawn. This creates economic difficulties because fishing, processing, and regulation must be flexible enough to allow quick adjustments.

28. For sockeye, pink, and chum salmon, which leave coastal waters before growing to a valuable size and are available to the fishery only during the few weeks

when they approach their home streams (during which they grow little), "yield-per-recruit" management has little or no part to play. For the two species chinook and coho, many of which remain in coastal waters throughout their lives, questions of how large or how old to catch them do arise, inextricably linked with the problem of letting enough spawners through. For all five species there are considerations of quality to take into account.

29. *Artificial propagation* — Means have now been developed for increasing the abundance of Pacific salmon by various artificial means. Indeed a "salmon enhancement" program bulks very large in the government's plans. It is mentioned here in order to note that even if it is successful in bringing about major increases in salmon production, it will not lessen the problems of regulating the fishery, either for conservation or for economic purposes; it will only alter the numbers of salmon to be dealt with.

30. *Too much fishing power* — The Pacific salmon fishery presents a classic example of the overcapitalization which plagues "common-property" resources, especially those that offer as much prospect of profit as this does. The fishing power is so great that it is not uncommon for fishing to be permitted for only 1 or 2 days in a week. In one instance it was calculated that if fishing was permitted for 6 days, it would take about 98% of the run — and this without increasing the number of boats, increasing the amount of gear each could use, allowing fishing in closed areas, or relaxing a number of other restrictions. There are problems of reconciling the interests of various types of fishing units — gillnetters, trollers, seiners, or combinations. There is need for enough fishing power to harvest good "runs" as well as poor, enough to provide the flexibility mentioned above (paragraph 27). It is not easy to devise a regime of regulation that meets all these difficulties. It is clear, however, that the Pacific salmon fishery is one in which limitation of entry is needed. The attempt to introduce it is described elsewhere in this symposium.

Recent Trends in Canadian Fisheries and their Management

31. *Many other fisheries under regulation* — The last two sections — international fisheries in the Northwest Atlantic and Pacific salmon — do not of course exhaust the list of fisheries under regulation. There are many others, some very important, some minor. The great majority have reached a stage of development at which it is necessary to limit the catch or the fishing effort to maintain the yield. Others have not reached this stage and are not subject to limitation, and still others remain to be developed commercially. Overcapitalization is common and the need to limit entry is recognized in many cases. We shall return to this, the main subject of the symposium, after a brief mention of some of the problems and complexities that face the development of effective regulations.

32. *Improvement of scientific background* — The management of fisheries, regardless of its objectives, is plagued by inadequacy of both information and theory. Management has thus far been largely on a stock-by-stock basis. In some cases fisheries depend almost entirely on one stock but these are the minority; the majority of the great sea fisheries take more than one species at a time, frequently more than one stock of the same species, and, even in the single stock most sought after, many sizes of individuals including some too small to market. As a result there are many discards, sometimes well over half the catch, on which it is very difficult indeed to get adequate data, but which constitute not only serious waste but also significant mortalities affecting calculations of yields. At the moment a strong effort is being made to improve the data base; this is one of the few areas in which expenditures are increasing and hopefully additional benefits will be derived, now that jurisdiction has been extended, by requiring better data as a condition of the licenses under which vessels of all nationalities fish. However, we still have a long way to go to get adequate catch statistics and sampling.

33. With better basic data, improvements will still be needed in the theory concerned with the reaction between competitive stocks or species and between predator and prey — fields in which basic data and theory are both lamentably weak. There is also room for a great deal of improvement in our knowledge of the oceanographic background for distribution and movements of fish stocks. To regulate fisheries well it is necessary to distinguish the effects of fishing on the stocks from the effects of environmental factors. It is, of course, desirable to predict oceanographic changes and their effects on fisheries; it is too much to expect yet but it will come eventually. Thus it is readily seen that more research and innovative thinking are needed.

34. *Technological advance* — The last few decades have seen many technological advances in the catching, transport, and processing of fish. These advances affect not only the equipment and manpower needed by the fisheries, but also the kinds of fish that can be caught, when and where they can be caught and when, where, and in what condition they should be landed for the greatest economic and social advantages. The technological advance still continues and will do so for many years. It is essential that the regulation of fisheries to maintain the yields be done in such a manner that it is not so conservative an influence as to discourage the innovation Canadian fisheries need, depending as they do on exports in a competitive world. A balance must be kept between restriction necessary to maintain the resource at a productive level and the flexibility needed to encourage innovation.

35. The balance can be kept only if there is thorough and frank exchange of views between both levels of government, fishermen and processing industry, and between various disciplines. Because provinces are

traditionally concerned with development and because on both coasts (especially the Atlantic) fisheries have an important influence on community development, close federal–provincial cooperation is essential. Whenever there is a major change in technology, the biology, the economics and sociology, the engineering, and the administration of fisheries are all affected, so a great deal of effort must go into reconciling different points of view with the needs of fishermen and industry in the development of policy. Progress is being made in Canada in this field but we have to keep trying; we must not slacken our efforts.

36. The scope of the technological change is exemplified by what has happened in the last few decades in the vessel fisheries of the Atlantic coast with which I am most familiar. The last few decades have seen the disappearance of the vessels on which I sampled haddock as a graduate student (wooden sailing vessels doing hook-and-line fishing with one- or two-man dories) and their replacement by a larger fleet of larger (140–160-ft) diesel-powered steel trawlers — first "side trawlers," now "stern trawlers," both capable of fishing in all but the worst weather and of catching some new species virtually untouched by the hook-and-line fishing (e.g. redfish or "ocean perch," various flatfish). Their relatively steady year-round supply of iced fish is adapted to support plants on shore processing fresh and (mainly) frozen products which have come to dominate the groundfish industry, although some salted fish are still produced. The next step, which is now imminent, is the enlargement of the fleet to include still larger trawlers with freezing and/or processing equipment to tap more distant fisheries resources or to exploit species (e.g. squid or silver hake) that, for acceptable quality, must be processed at sea immediately after they leave the water.

37. Concurrently with this transformation of the large-vessel offshore fleet, there has been an equally important development of a large fleet of diversified smaller (45–120-ft) vessels — mainly fisherman-owned with the help of both levels of government, mainly wooden and locally constructed. They have been well equipped with electronic devices for navigation and fish finding and with new fishing gear (powered longlining and purse-seining, midwater trawls, "Scottish" or "Danish" seines for groundfish, deep-water lobster and crab-trapping, etc.). They have been used to develop many new fisheries (offshore scallops, herring, crabs, shrimps).

38. There has been similar innovation on the Pacific coast both in vessels, electronics, new gear, and new fisheries. On both coasts the innovation, in all its aspects, is continuing and will continue. The extension of jurisdiction, by assuring the availability of resources to Canadian fishermen, is supporting a renewed spirit of adventure in fisheries development. And, with it all, some small-boat inshore fisheries remain almost unchanged over decades — notably the important lobster fishery of the Atlantic coast. The overall result is a greater complexity in the fisheries as a whole and often in the part played by the individual fisherman.

39. *New opportunities to regulate fisheries with an eye on the market* — With the extension of jurisdiction have come new opportunities to regulate fisheries so as to maximize the value of the catch. Herring in the Bay of Fundy area are a case in point. Foreign competition in fishing has gone. A voluntary arrangement by a fishermen's organization has spread landings over a larger period making processing for food more profitable. The seining of herring for reduction has disappeared. Catches have been maintained and the price paid to the fishermen multiplied many times.

40. Since we no longer must rush to get our share of the catch in the face of foreign competition, we are now free to harvest fish when they are most valuable. It may be expected that fisheries regulation increasingly will take into account the seasons — when and how long — during which landings can be processed most profitably, regarding costs, quality, and demand. This trend is reinforced by one towards carrying Canadian processing to higher and higher levels, including some specialty products sensitive to the quality of the raw material. Together these trends make a further contribution to the innovation and to the complexity of the fisheries picture.

41. *The trend towards limitation of entry* — In spite of these complexities and the flurry of innovation, there has been an increasing appreciation of the possible advantages of economic rationalization through limitation of entry. This has not had unanimous support but has become accepted as part of the fishery regulation picture. It has applied mainly to cases where the fishing power greatly exceeds that needed to harvest the resource; it has been evident in some other instances in a reluctance to issue licenses (e.g. trawler licenses) for expansion of Canadian fishing power, where such an excess is not evident and the motive must be either to discourage overcapitalization or to protect other users of the resource.

42. The program of limitation of entry in the British Columbia salmon fisheries is described in a later paper in this symposium by G. Alex Fraser. After some years of consideration it was initiated in 1969. It was an obvious case, fishing power having become so great that to let enough spawners through, it was sometimes barely safe to permit 1 or 2 days a week and both information and control were impaired. When the program started, records indicated that many fishermen were "in and outers" and it seemed that displaced fishermen could be absorbed in the local working force. The program attempts a long-term reduction in the numbers of fishing vessels and the fishing power. It has had some success but needs further development.

43. The other case that was given serious consideration at about the same time was that of the Atlantic lobster fishery, the most important of all for the local

small-boat fisherman in the Atlantic provinces. Because of the difficulty of finding other employment, a program similar to that on B.C. salmon was not adopted in spite of evidence that the fishing power in many areas was at least twice as great as was needed. Steps were taken to freeze the number of fishermen and of lobster traps per fisherman. The two cases are opposites in many ways. In the lobster fishery alternative employment is more difficult, operations are more localized and less mobile, and lobster fishing is more often part of a complex livelihood, frequently including farming.

44. There is no doubt that both these cases will be reconsidered and furthered, as will other cases of license limitation. There is need, however, for clearer thinking about the objectives, the techniques, the problems, and the effects of limitation of entry to fisheries. Hence this symposium.

Economic Rationalization through Limitation of Entry

45. This might be thought to be where the background paper should end and the biologist–administrator bow out. Before doing so he would like to give some views on objectives and to pose some of the questions that must be answered if limitation of entry is to be effective and beneficial to society.

46. *The objectives of fishery regulation* — There have, in my opinion, been a great many misleading statements about what have been and should be the objectives of fishery regulation. I refer to assertions or inferences that it has pursued the objective of the welfare of the fish rather than of the fisherman or of society. A half century with fishery biologists and administrators, as well as fishermen and fish processors and politicians, has failed to reveal to me any concern for the fish except as a means of providing livelihoods for fishermen and for those in fish processing and other related industries (shipbuilding, manufacture of gear and equipment, repair, provisioning, etc.) — one might say the fishing communities. Concern for the fish seems to be limited to a few cases of emotionalism like the current hysteria about marine mammals. This is not likely to spread to true fish and to shellfish; human sympathy is not extended so readily to the cold-blooded animals, although some of them are very impressive.

47. Fishery regulation is seldom seriously concerned with cases where stocks are in danger of extinction; fishery regulation exercises its influence at higher levels of abundance and is concerned with keeping those levels high enough to support profitable, continuing, commercial exploitation, i.e. livelihoods for people. As I said in my introduction the objective of fisheries management (regulation) has always been to obtain from exploitation of the resource the greatest possible benefits to society as a whole, and, more particularly, to assure the economic welfare of fishermen and fishing communities, including the fish processing industry and the fish trade.

48. *Economic rationalization and livelihoods for people* — To explain the emphasis on livelihoods for people it should be noted that proposals for fisheries regulations are normally formulated by biologists and/or economists and/or administrators in consultation with fishermen and the processing industry; the decisions to pass the regulations lie with politicians who are strongly influenced by popular demand, especially of fishermen and fishing communities. Thus it has been inevitable that the ultimate objective of fisheries regulation has been the welfare of fishermen and fishing communities. This is part of the democratic process and difficult to oppose. It is specially evident in those areas, so common on our Atlantic coast, where small long-established communities are almost completely dependent on fishing. This point of view is a fact of life in our efforts to rationalize the fishery and strengthen it economically.

50. The doctrinaire economist, viewing a fishery, might be inclined to count wages (including returns to fishermen) as a cost and to concentrate on maximizing the "economic rent" and preventing its dissipation; the fishing community regards employment as a benefit and cares little about the overall profit as long as it is enough to keep the whole show going. The economist is prone to regard labor (including fishermen) as mobile and to say that labor should seek some other occupation if its return is below the national average; most fishermen are reluctant to leave either their occupation or their locale, and, in recent years, get no encouragement from the fate of many who have left the small community for the large.

51. These points of view must be reconciled if any program of limitation of entry is to be beneficial and acceptable. Various divisions of the fishery, whether by area, by species or group of species, or by type of operation, will have widely differing economic, sociological, and biological problems and will require widely differing programs.

Conclusions

52. It is time for the biologist–administrator to bow out. A summation and a suggested series of caveats for consideration seem to be in order.

53. Most sectors of the fisheries need limition of fishing effort for purposes of maintaining the stocks and yields at their optimum levels; for economic purposes (and even in some instances, like Pacific salmon, for practical biological management) this usually requires some degree of limitation of entry. Developing or new fisheries are excepted, but even in these it may be desirable to guard against overcapitalization. Problems to be considered in formulating programs of limitation of entry include the following, with no implication of relative importance or urgency:

54. *Soften the immediate impact* — If the existing number of fishing units needs to be reduced drastically, the reduction should be phased over a number of years to ease the effects on fishermen's assets or employment.

55. *New entrants* — It should be possible for the young or for other interested individuals to enter the fishery. Limitation of licenses of fishing units rather than of fishermen makes it possible for new entrants to buy their way into a fishery, while at the same time protecting the assets of the retiring fisherman or the fisherman's widow. Such a scheme would need safeguards against monopoly. It seems desirable to favor the owner–operator.

56. *Innovation* should not be discouraged — whether exploiting new stocks, using new methods or serving new markets — by too tight limitation. It seems there should be flexibility and some surplus fishing power.

57. *The versatile fisherman* — One of the difficulties seen by fishermen themselves is that limitation of entry to one fishery at a time could make it more difficult for the fisherman who depends on taking part in more than one at different seasons. Yet this versatility may offer maximum economic efficiency.

58. *The part-time fisherman* — There is resentment on the part of fishermen who depend entirely or mainly on fishing for their livelihoods against "moon-lighters" who already have a good living in another occupation; one can sympathize with the resentment and would not mind if they were casualties in a limitation of entry program. There is, however, a very important group making their living in part from subsistence farming and in part from fishing. It would be a tragedy if license limitation did away with this. It might destroy whole small communities seemingly depending on resources, both land and sea, too meagre to use any other way and with a too rapidly declining culture of independence and freedom.

58. *Who gets the "rent"?* — If economic rationalization through limitation of entry establishes a privileged group of fishermen with high personal incomes, it becomes possible by one means or another to collect a rent. What means is best in any one case? How much? Is it reasonable to expect that the rent should go to society (government) at least to the extent of covering, if possible, society's costs in maintaining the resource? Still more?

59. *Fishermen's incomes and numbers* — Limitation of entry programs will affect the balance between the numbers of fishermen and their average incomes. A serious and difficult series of decisions is involved on the objectives and means, both differing from case to case.

60. The time for the biologist–administrator to bow out is perhaps long overdue.

Development of Economic Theory on Fisheries Regulation[1]

ANTHONY SCOTT

Department of Economics, University of British Columbia, Vancouver, B.C. V6T 1W5

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A survey of the economic literature of fisheries regulation shows that little of analytical value for the comparison of alternative regulatory techniques has emerged. The suggestion that the general literature on regulation, and on public choice, has something to contribute to the understanding of alternative regimes produces eight criteria. These are applied to the choice between two systems of restricting entry: a tax, and quotas. The transactions costs of the two systems are also investigated. The hypothesis is formed that the eight criteria, plus expected transactions costs, give the edge to a quota system; but this is only illustrative of the approach.

Key words: regulation, management, costs, quotas, taxes, revenue, licensing

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D'un survol de la documentation économique sur le contrôle des pêches émergent peu de choses de valeur analytique permettant de comparer diverses options de contrôle. A supposer que la documentation générale sur le contrôle et sur le choix public puisse contribuer à la compréhension de différents régimes, on peut en déduire huit critères. Ces critères sont appliqués au choix entre deux systèmes de limitation de l'entrée: taxe et contingents. Nous examinons les coûts d'opération des deux systèmes. Nous énonçons l'hypothèse que les huit critères, plus les coûts anticipés des opérations, donnent l'avantage au système des contingents; cela ne sert toutefois qu'à illustrer la méthode d'approche.

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I. Introduction

SERVING as a background paper, this essay has an unavoidable bibliographic flavor. Its subject is not the emergence of fisheries regulation, a subject yet to be tackled by academics, but the development of the economic theory related to that subject.

My general impression is that this theory has not progressed very far since it was taken up with enthusiasm in the 1960s. However, now that extended fishing zones, out to 200 miles or beyond, are to become the rule, there is a new imperative to combine the original theme of fishery economics with the economic theory of regulation in industrial organization literature. This paper's reminders of what has already been done may enable students to take up the challenge. There is now a widespread demand, among all L.O.S. participants, for advice on methods of regulation and sharing. In the absence of appreciation of the progress and mistakes already made, the danger is that the industry will relapse to the labyrinth of ad hoc, contradictory, mercantilistic, and ineffective regulation of the not-so-distant past. Inertia may then make it impossible to move to a clearer set of institutions and rules.

The paper is organized as follows. In Section II I present a brief historical survey of fishery economics to identify the four main themes with which the broad literature (since World War II) has been concerned. In Section III I examine more closely the regulatory literature. In Section IV I turn to a small part of regulation, that having to do with restriction of entry. And in Section V I narrow down to the economic literature on property rights in fisheries. All this is reinforced by a long bibliography, pieced together from both direct consultation and secondary sources. It is weak on official reports on proposed or actual regulatory schemes; these are hard to locate at the best of times and I have had to work from an Australian base where the "tyranny of distance" has compelled me to make do with what diligent and helpful librarians have been able to collect.

II. Themes in Fishery Economics

It is now over 50 yr since Warming, followed 25 yr later by Gordon and others, and assisted by fisheries biologists and administrators, lifted the study of fisheries economics out of its previous obscurity. Till then it had been the occasional subject of academic and policy papers (see especially MacGregor 1949), many of them applying the concepts of such economic fields as industrial relations and labor markets (Jamieson and Gladstone 1950; White 1954); agricultural economics

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both econometrically and in studies of supply organization (in the studies and routine reports of official fisheries' departments); industrial organization, especially marketing (Gregory and Barnes 1939); and, of course, economic history (Innis 1940).

Much of this previous work was brought to bear on the common-property insights of Gordon, Popper, and the rest in September 1956, in the exciting I.E.A./F.A.O. Fisheries Economics Round Table assembled in Rome. Its proceedings were ambitiously entitled, justifiably as it then seemed, *The Economics of Fisheries,* and were brilliantly edited by R. Turvey and J. Wiseman. In addition to those whose names are listed therein as contributors and discussants, the Round Table had the good luck to attract, at least for a few days, E. A. G. Robinson, G. Haberler, E. Lindahl, and, although I am less sure about this, some additional heavyweights such as D. H. Robertson and B. F. Haley, who had been the leaders of the I.E.A.'s first congress (held a week before in Rome). These great men knew little or nothing about the new field for applied economics. But they did know about Knight's theoretical work on external economies and property (Knight 1924) and they usefully prevented a tendency among new enthusiasts to blame every unusual feature of the fishing industry, anywhere, on the ubiquitous common-property characteristic.

It is not necessary, or interesting, to set out the history of fisheries' economics since that time. One good reason is that specialized accounts have recently been published by Pearse (1978), Butlin (1975), and Peterson and Fisher (1977). V. Smith's new anthology (1977) includes several articles with good bibliographies up to their date of publication. Most F.A.O. conference proceedings include accounts of what has gone before; for examples see the earlier background papers by Scott and Dickie in the Hamlisch volume (1962). And always, there are adequate histories of the subject attached to available official reports and background working papers.

The exciting new point of departure, mentioned above, was common property. F. Knight and Pigou had already debated this subject, but it had not been applied in any interesting analytical way by economists to such other resources as common ranges or pastures, oil wells, water tables, the oceans, or the atmosphere — although of course many applied economists and legal scholars recognized the problems for centuries.

S. Gordon touched off a wave of theorizing. Carefully applying Knight's two-road example to two fishing grounds, he demonstrated that on any fishing ground the unrestricted entry of units of effort would lead to an unusual *bionomic* equilibrium (Gordon 1954; Cheung 1971), in which the resource would yield less fish than its capacity, and labor and capital would be overapplied so that their marginal product in fishing would be below opportunity cost. Gordon and others offered these results to help explain poverty among fishing peoples; and the prevalence of the share or lay system to distribute fishermens' incomes of vertical integration between fishing vessels and buyers or packers (Cassady and others in Turvey and Wiseman 1957). Another group, viewing the "dissipation of rent" as a loss of natural capital, stressed instead that common property was inefficient in that it prevented controlled allocation of stock or catches over time, either within the season or between generations (Scott 1955, 1972, and in Turvey and Wiseman 1957; see also Ciriacy-Wantrup 1952).

The evils of common property having been identified, what should economists recommend? This was the second theme that got its start in the 1950s. Those who followed Gordon and Knight naturally tended to favor the invention and application of new property rights, similar to those that had brought to an end common land-use. Those who had been brought up on Pigovian welfare economics favored taxes or subsidies to bridge the gap between private and social net marginal products.

These methodological differences, however, soon gave way to the more practical issues of the choice among taxes, charges, and some feasible form of property rights. The first lesson being taught was that existing ad hoc fisheries restrictions (of gear, open season, etc.) were more inefficient than any of property rights, subsidies, or license fees. None of the major policy instruments made much legislative headway; instead, whatever progress was made was in convincing policy-makers that many restrictions were ineffective or wasteful, whereas other, novel, restrictions (such as "eumetric" net-mesh controls) might increase every fisherman's potential catch (Hamlisch 1962; Turvey 1964); Crutchfield and Zellner 1962; Crutchfield 1959, 1961, 1965; Beverton and Holt 1957; Pontecorvo 1966).

What did become disconcertingly clear was that among biologically and legally trained administrators, diplomats, and decision-makers, the "economics" of the fishery was regarded as applicable to distributive, "for-whom?" questions. The fishery economist expected to justify his client's fishery goals, such as effectively excluding potential fishermen from one social or economic grouping and conserving or protecting the stock for exploitation by another.

This distributive bias was also revealed in the 1950s debates into the international law of ocean fisheries, and the doctrines ("freedom of the seas"; the "abstention principle"; coastal states' rights; and so on) invoked in the great issues debated during the first U.N. Law of the Sea conferences (1958). Although expounded in Benthamite law-reform rhetoric, the doctrines usually collapsed to catch-phrases favorable to fishing rights for particular nations. (Christy and Scott 1965; Crutchfield 1966; McDougal and Burke 1962). Even the great campaigns of the 1970s to keep the oceans from being enclosed into extended national territory or exclusive resource zones were advanced, and received, more as distributional principles ("the common heritage of mankind") than on efficiency grounds (Christy 1973).

As the second Law of the Sea conference approached, the efficiency principles (strongly advocated by biologists) of keeping known biological stocks under unified management faded away: ethical and distributive arguments (usually about "rights") replaced them almost completely. Even today, when more economists have reinforced the original group who worked on alternative regional and international fishing policies and institutions, it apparently comes as a surprise to lawyers, diplomats, and politicians that fisheries' economics is not exclusively devoted to assembling the economic aspects of nationalistic and protective briefs.

If fisheries economics is to be saved from such a fate, its salvation will have come from bioeconomics, to give it the title of C. W. Clark's monograph on the dynamic management of renewable resources (1976). In my bibliography, the selection of items listed will suggest how venturesome this new breed of fishery economist has become (Clark 1973; Clark et al. 1977; Spence 1973).

As S. Gordon indicated in his 1954 article, the mathematical contributions of biologists pointed the way to economic analysis. Not only was the form of modeling familiar to those economists who had some familiarity with demography and capital theory, but the methodology, with its strong deductive approach (perhaps arising out of a paucity of data) to broad generalizations, promised a welcome collaboration between the two groups (Schaefer 1954). This probably reached its height during the period when economists were studying the works of Beverton and Holt (1957; see Dickie in Hamlisch, 1962, and Turvey, 1964). Since then, one feels that the mathematical bioeconomists have pressed ahead, beyond their data, more than is familiar or acceptable in biology. This has been particularly true as policy-oriented economists have veered from prediction to optimization, employing successively calculus, the calculus of variations, programming and control-theory formulations (Crutchfield and Zellner 1961; Plourde 1971; Gould 1972; Clark and Munro 1976; Quirk and Smith 1970; Scott 1970; Smith 1968, 1969; Neher 1974; Bell 1972; Lewis 1977). What *has* held the groups together is the flourishing use of the computer and the joint application of its program to the newer ecological and management assignments of fishery scientists, and to the numerical solution of policy problems involving both biological and economic submodels (Hannesson 1974a; Royce et al. 1963).

III. The Economics of Fishery Regulation

In this section I will briefly review the economic theoretic literature on forms of regulation of fishing. I can be brief because this literature does not, it now seems to me, constitute a coherent body of theory at all. The majority of models introduce controls in a purely formal, or negligently offhand manner, changing a net price or adding a constraint. Thus, most of the theoretical "regulatory literature" simply arises in the process of examining models' comparative static or dynamic properties. It is not part of a literature on detailed, multiobjective, real-world, regulatory options.

On the other hand, there is practical literature, much of it by well-known economists, on instruments of regulating fisheries, with some reference to some of the probable consequences of each instrument. Reflecting their authors' wisdom and experience, this literature does explore some expected consequences of various proposals. But it is very partial; rarely does it start with a set of criteria and compare the alternatives systematically. Furthermore it is not placed in a general-equilibrium framework. In these respects, it has been dramatically overtaken by the new economic literature on pollution abatement and environmental protection. (The best-known systematic comparisons [Scott in Hamlisch 1962; Crutchfield 1961; Brown 1974]; do escape some of these flaws, but they were written nearly 20 yr ago).

Why are fisheries regulated? Caution comes with age, and I am not so quick as I was in the early 1960s to explain motives. Furthermore, because any public intervention into a market economy, even into a faulty-market sector like the marine fishery, will probably induce further interventions to prevent evasion, or forestall unwelcome adjustments, observed action or apparent effect of a regulation may not tell us much about the motives that originally inspired it.

However, we are not deaf and blind, and we do know what has been claimed for some new regulations when they have been proposed. Furthermore, we do know something of the situations that existed, or were feared, before regulations were instituted.

First, regulations have been instituted to encourage what is now called "X-efficiency." Declining catches, stocks, and profits have indicated that the industry had fallen from its national production possibilities path, and an "overfishing" problem has appeared. To condense a well-known theory, the pressure of fishing has reduced the stock below the level that would offer larger catches.

The practical measures for controlling existing fishing mortality depend for their effectiveness on reducing the "effort" to which stock is exposed. Since effort is the arithmetical product of the number of units (usually, vessels), times the length of the period they are in use, times their "catching power" (proportion of the stock they are capable of catching per unit time), effective mortality regulation depends on reducing one or more of these effort components while preventing the others from making a compensating increase.

Among the best-known techniques for reducing these components are reducing the number of vessels (a relatively new control); reduction in their size or motive power (thus reducing the period of time the vessels can remain in contact with the stock); closing for certain seasons in particular areas; and prohibiting the use of certain effective or "destructive" types of gear (thus reducing vessels' catching power).

Obviously, the effectiveness and cost of these controls on the components of effort differ. We shall discuss controlling the number of vessels later in this survey; it has been advocated for a long time and has economic aspects that are more interesting than the others. Control of the size, speed, or fishing power of vessels is a very common device, being relatively easy to enforce, and having popular distributive aspects. Closed areas and seasons are of doubtful effectiveness, especially if the fish do not remain to be caught in the open seasons, or do not migrate from the protected grounds to be caught in an open area.

Under favorable circumstances, all these measures can increase the yield by increasing recruitment or reducing mortality. They compel the industry to make an investment in the stock, cutting down immediate catches to obtain larger catches later on. Whether such investments are justified by their eventual benefits has recently been extensively studied. The application of bioeconomics has shown how control theory can be applied to planning the extent of the original sacrifice and the timing and form of the eventual gain (see Crutchfield and Zellner 1962; Quirk and Smith 1970; Southey and Scott 1970; Plourde 1971; Clark and Munro 1976, and many others). Numerical methods have, by the use of the computer, also been used in these studies (Hannesson 1974a; Loose 1978; and a very large number of unpublished official studies).

Compulsion is justified because the fishery is common property, and fishermen will not be willing to sacrifice a present catch for a later benefit, if they believe the benefit will not be captured by themselves. Compulsion is also sometimes justified because the stock is a public good, in that locating (and sometimes catching) fish is easier for all the fleet when the stock is conspicuous and dense, than when it is small.

However, the net benefit of regulation can easily tend to zero, if the benefits are reduced by increasing fishermen's outlays on doing whatever is permitted to take the larger catch. These permitted adjustment costs may include expenditures not only on vessel and gear, moving closer to ports, storing fish on board longer, but also on reequipping their vessels to make them usable in other seasons in other fisheries.

The same increased costs result from attempting to ignore the components of effort, and instead setting overall catch quotas. This technique, pioneered for halibut on the West Coast, allows the fleet freedom to combine the components of effort, fishing wherever and however the owner chooses. However, the larger catches due to quotas have encouraged fishermen to increase the number of vessels, improve their speed, gear, and so forth. Consequently, the authorities, to protect their quota, have been forced to shorten the catching period. In the end, therefore, overall quotas have led to a swelling of costs just as have control of effort components.

Cost is the chief theme of economists' criticisms of all controls to deal with overfishing. Although they do increase total catch (and consumers' surplus) the associated rent invites a cost increase of the same amount. Crutchfield has pointed to other defects, including distorting the market by shortening the landing season, preventing "progessivity" by prohibiting the new techniques or vessel types and, as already mentioned, forcing owners to build adaptable rather than specialized vessels, and to base themselves on nearby, rather than home, ports.

It follows that the need for the authorities to multiply their regulations increases exponentially. "Overfishing" regulations that reduce one component of fishing effort induce further controls to suppress increases in other components. Also, because it is becoming obvious that the setting of an overall quota encourages private investment to outwit or anticipate competitors, rather than to increase the quality, value, or amount of the catch, administrators are tempted to regulate or forbid these investments as well.

A second type of regulation, already referred to, is to increase the quality, weight, or size of the individuals in the annual catch. Most of those in use are connected with the timing of the catch, and have the ultimate effect of postponing harvesting of an individual until a later season or year. For example, a closure may prevent fishermen, competing with one another for the available catch, taking individual fish when they are too small, or in poor condition, or so remote from the port that they must be held in value-reducing storage or board. This kind of regulation, applied to seasonal timing, is common for crustaceans and molluscs, and for migratory fish. Applied to interseasonal deferment, its application has been gradually broadened following studies of the possibilities of "eumetric" fishing, allowing small fish to grow in weight, quality, and value. Other types of regulation may work to reduce the costs of fishing rather than to increase the quality. For example, the costs of catching a fish inshore may be less than when it is intercepted on the high seas.

These controls take the form of a social investment, and must be evaluated as such. They have an immediate cost in sacrificing landings, to reap an ultimate gain in net landed value. Because of the common property characteristic of fisheries, individual fishermen will not make such investments (sacrifices) unless forced to do so.

Third, fishery regulation is often redistributive, or, to describe the same motivation, it is protective of chosen groups. This is well-recognized in the literature. The Scott and Crutchfield surveys mention the protection of fishermen by government regulations that specify maximum size of vessel, permitted gear, motive power, closed season, area of catch, or permitted species. In particular local circumstances, such specifications tend to exclude competition from particular outside fishermen. Alternatively, those who may, or may not, fish are sometimes mentioned explicitly. We have heard of protected groups described in terms of their age, race, language, and of course nationality.

This protective goal obviously conflicts with any efficiency goal and, I will argue, is probably the more powerful. Its attractiveness will be tempered only by recognition of the costs it imposes on others. In some cases these may be consumers, in which case we might have a situation analogous to farmers or utilities using natural or contrived monopoly to increase wholesale and retail prices (Weitzman 1974). Political means may be used to regulate such behavior. But, in most cases, the victims will be the excluded fishermen. Since they will be potential, not actual, entrants, without "historic rights" or visible connection with the fishery, they find it difficult to muster political support for relaxing the protective rules.

Water, the fishery habitat, is itself of course a multiple-use resource, and "protection of fishing" includes also protection of incumbent fishermen against foreigners, and against those who would seek other fish (mentioned at the end of this section). Furthermore, much policy is invoked and refined to allow the sharing of estuaries, rivers, and lakes between fish and commercial fishermen and the energy industries; waste-disposal interest; and sport fishermen (Marts and Sewell 1959; Crutchfield and Zellner 1962; Stephenson 1977).

Fourth, fisheries may be regulated to prevent the waste of labor and capital and promote the efficient allocation of resources. Governments have long been aware that in the fishing industry the number of fishing units tends to increase beyond the amount warranted by the expected catch. Three results were said to follow. Catch per unit effort being low, boat owners were unable to obtain the expected return from their investment. These low returns flowed (through the share system) to fishing hands, reducing their incomes to the "poverty" level (something less than their opportunity incomes elsewhere). Finally, with new entrants diluting the catch, existing vessels tended to reequip with faster motors and smaller-mesh nets and to sail from ports closer to the fishing grounds.

These results are often visible, but they depend on special conditions. In economist's jargon, free access to the common-property resource tends only to increase the number of multiinput units of effort until, at the "bionomic equilibrium" each unit adds less to the value of the harvest than in alternative sectors. Thus resources are allocated inefficiently among sectors.

But this does not mean that take-home rewards must be lower than elsewhere. Special factor supply conditions are necessary to explain low fishery incomes. Among those that have been suggested are asymetrical mobility (easy come, never go) and willingness to accept risk or variability in earnings. Such necessary conditions are often the basis of beliefs that identify those fishermen have special individual and social preferences. Alternatively, it is sometimes argued that many fishermen have such a strong comparative advantage (in endurance and skills) in fishing that their alternative incomes would be even lower (see Copes 1972 and earlier contributions on the Newfoundland fisherman; this subject was repeatedly discussed in the comments in Turvey and Wiseman 1957 and Hamlisch 1962).

Thus low incomes do not prove that labor and capital are wasted in the industry; fishermen may just be low-income people. The usual evidence of waste advanced to justify regulation is more pragmatic: the catch could be found and brought in, with the same personal cost and equipment wear and tear, with fewer units of effort. Crutchfield and others have frequently made this observation with respect to salmon — Alaska's salmon catch could be taken with about 25% of the 1960s levels of effort; British Columbia's with 50%; Puget Sound with less than 50%. The latest numbers come from a new Ph.D. thesis: in the Skeena River, a sole owner who could not vary the number of boats in use over the season could dispense with about 15% of the present gillnet fleet (Crutchfield and Pontecorvo 1969; Loose 1978).

Economists' surveys of fishery regulation make much of the power of government action to remedy the wastes of common property and similar market failure. But I do not believe that an increase in efficiency in resource allocation very often enters into politicians' motivation for intervening in the fishery, or in any other sector. Indeed, as long as some of the other goals mentioned here are satisfied, politicians, if they understood that it existed, would probably approve of the redundant absorption of labor and capital into fishing. In any case, they are understandably unenthusiastic about measures that may displace people from jobs, close down plants, or empty ports.

This disenchantment is reinforced by growing confidence in some of the approach of the general economic theory of regulation, especially as advanced by G. Stigler and his associates, and its cousin the theory of public choice, as represented by J. Buchanan, G. Tullock, and W. Niskanen.

While most public utility regulation is concerned with the costs and price setting of existing firms, some of it is concerned with entry of new competitors. Regulation is not treated as a free good, but as a commodity that is supplied by politicians (ultimately) and administrators and tribunals (more directly). There are two large parties whose demand is supplied: the members of the regulated industry, and the public. A common conclusion is that when price or costing choices must be made, industry is favored over the public: in the long run the regulatory institution finds itself protecting the controlled industry.

More recent development of this theory, emanating from the public-choice approach, start with the preferences and constraints of the decision-maker. Why does he "protect" the producer, or allow himself to be "captured" by the industry he is supposed to be policing? (See Peltzman et al. 1976.)

This new development, searching for both maximand and constraint, seems to me to point the way for profitable research into fishery regulation, and for collaboration in the fields of industrial organization and the economics of law. Clearly, rate-setting for Bell Telephone is not a very similar process to determining the stumpage rate in public forests, or the price of butter, and is even more unlike the determination of closed seasons and areas in fisheries. Yet in all these processes, we have similar procedures: information gathering; hearings, negotiation and bargaining; and monitoring and enforcement. And we have bureaucrats who gain by a proliferation of the demand for these procedures, institutionalized as expanding departments or commissions. The decision-maker himself could easily be shifted from one job to another. What uniformities would we see in his decisions? What differences in constraints would alter his behavior if he became a fishery regulator?

I am not aware that much progress has been made on this question, except perhaps with respect to studying the behavior of fisheries' spokesmen at L.O.S. preparatory meetings and caucuses. (Although these could not really be called "regulatory" procedures, they do provide clues. Christy and I were once criticized for identifying the little group of fishery diplomats (1965), but we did not proceed to analyze their group behavior. And I was once included in a Chicago University conference on industrial regulation, to the indignation of the invited audience, who could not see enough similarity between fisheries' and telephone regulation problems to justify combining them on the same panel.)

Probably the difficulties of applying regulatory theory of fisheries are these: (1) in many regulatory actions, the public interest is not represented, or even known to exist; (2) the industry is not always split between two industrial classes, but between fishermen living in different areas, or using different gears; (3) technical information is not provided by the adversaries, but by the regulatory commission; (4) some decision-makers in fisheries, like those in forestry, are able to resist capture by the industry because their own utility functions, deriving from their training and profession, inclines them to attempt to impose their own ideas of biological "conservation" and perhaps "economic efficiency" on an industry where no party is advocating these aims. Existing studies of the U.S. forest service, in their *regulatory* capacity, might support this generalization.

IV. Restriction of Entry

In the preceding section, it was shown that open-access fisheries, subject to depletion of stock, deterioration of quality, and falling incomes, have been proposed for and subjected to several kinds of direct regulation. Four lessons emerged.

First, regulation is most acceptable when it protects fishermen's private investments. The best instances of these private benefits are the exclusion of competition from vessels other than those who, having crews with the same social or economic characteristics as the incumbent fishermen, or using the same gear as those already exploiting the stock. To a lesser degree, it is also welcome if it helps to reduce the costs of fishing, or raises the quality and value of the fish.

Second, the control of quantity and quality, through the control of the application of effort, loses its value as a social investment as fishermen adjust to the chosen regulation, by costly investment of their own. This is partly because the number of vessels is not controlled.

Third, in general, neither the government nor the participants have any concern about the inefficiency of the exploitation of common-property industries. The two points mentioned above suggest that political support would be given to restrictions on the overapplication of inputs if, in the form of restrictions in entry, they would work to the advantage of incumbent fishermen. They might do this by cutting down the necessity to intercept or anticipate their rivals on the fishing grounds, cutting their costs, or need to invest in costly equipment, increasing their catches, or increasing the value of the fish. But there is no political interest in the general-equilibrium point that common property leads to a distorted allocation of labour and capital between fishing and other industries.

Fourth, even less, because it is rarely discussed, is there any interest in the idea that the maximization of the present value of a fishery might take the form not only of sacrifice of present catches for increased future yields, but also take a "pulse" or cyclical form. This would take advantage of noncovexities in fishing effort costs, in revenues, or in the timing of the most rapid rate of increase of stocks after they have been heavily fished (Gordon 1957, 1958).

These points suggest that, although economists may favor entry restriction, neither the practising politician nor the individual fisherman is particularly interested in such a policy. Groups, as opposed to individuals, among processors, vessel owners, and crew members may have leaders whose own positions would strengthen their own strategic bargaining position over fish prices, taxes, subsidies, or other aspects of their position vis-a-vis other interest groups or the government, if *particular* schemes of entry restriction are adopted. For example, a union or co-op might approach closed-shop status; and companies might achieve a buyer's ring or cartel. But *individual* fishermen or vessel owners, like individual voters, would not stand to gain much from entry restriction. Thus we must look to statesmanlike economists and biologist administrators to convince politicians that efficient entry restriction is economically desirable.

In this section, I pull together some lessons, concerning restriction of entry, arising from experience with, attitudes to, and theory concerning, methods of entry restirction. Before doing so, however, we should note that there are many other problems of uncontrolled fishing than those that have emerged in discussing the motives for regulation. Most existing types of regulation provide no answers to these problems; they remain as serious as before the era of regulation. Because they remain as challenges to any system of entry restriction, I will attempt to take them into account in what follows.

First among these is the misallocation of fishermen and efforts between grounds, the original problem posed by Knight and Scott Gordon. This may not be a problem if the fleets have a short range, and so need not choose between grounds. (One may ask, however, why a short-range fisherman would stay with a marginal ground when he can move to another port and use the richer fishery.) But, if vessels have a long range, spatial allocation (or dispatching) seems to be necessary.

The second is the allocation of the catch over time. The measures to be mentioned in this section can be used to close seasons, and could be used to close whole years to fishing. But goals for "pulse" (or cyclical) fishing have not yet entered the discussions of fisheries policies. This dynamic problem will be linked below with the dynamic problem of finding an entry-restricting system that will guide the fishery to a chosen equilibrium.

Third is the choice of methods to keep a balance between stocks of fish that are caught together (e.g. by seining or trawling). Levels of effort that may allow one fish to flourish may either overexploit or neglect other stocks. In the limit, one may be extinguished. This is getting attention today in the tuna–dolphin problem, but it has been of concern to biologists for some years, particularly where large factory-ship-base expeditions sweep up nearly every type of fish from the ocean floor. New types of policy, not yet proposed, are needed to bring selectivity to low-cost fishing techniques.

Fourth, there is the problem of the choice of size of stock, catch, timing, or species in international or transfrontier fishing grounds. The aims of domestic policies thus far have been simply to exclude foreign fishermen. But it is now possible that, even with exclusive extended fishing zones, a preferable policy might be to compromise between the implicit aims of all those nations exploiting the same stocks or region. Especially if the foreigner must pay for the right to fish, he may offer more if the country in whose waters he fishes allows him to seek, and take, the species he wants at the right stage in their growth at his own pace. Policies to deal with such questions are on the agenda of today's diplomats, but they have not yet emerged as distinct goals.

To avoid having to deal with the devising of detailed systems that will handle the need not only for economic efficiency and administrative workability, but also the four extra problems mentioned above, I shall narrow the main discussion in this section to the choice between a fee (or tax) on the one hand, and a transferable-rights system on the other. In the early pages I shall also avoid complex (multiground, multispecies, multination, or multigear) fisheries, but the practical reader should observe that I am not unaware of them and am struggling to introduce them systematically.

By confining myself to the tax-versus-right's question, I am putting to one side more arbitrary or discriminatory entry restriction systems, especially the "grandfather" systems. These discriminatory systems are usually proposed as a feasible scheme for confirming the fishing rights of existing vessels, crews, or owners, and reducing them by attrition. Scott (1962) and Crutchfield (1961) have discussed the characteristics and the advantages and disadvantages of this means of gradually phasing out excessive effort from an "overfished" stock (Pearse 1978). It should be seen as a type of transitional process. From a political point of view, it saves the government from forcibly ejecting "marginal" participants from the industry. From the point of view of economists (familiar with the adjustment problems of tariff reduction or industry restructuring), it reduces the obvious administrative and ethical problems of whether and how to pay compensation to those whose livelihood is removed by a change of policy. Compensation of a kind is indeed received: those who stick it out the longest find that their catches and earnings increase; while those who leave find equivalent reward in the blessings of retirement or of the Hereafter. However, these seem advantages of expediency only. From an ethical point of view, a grandfather system has the distributional morals of a tontine (Scott 1962).

From an efficiency point of view, as well, the grandfather scheme has little to recommend it. The fleet composition, aging, and changing as vessels and crews drop out, will (except by accident) differ from that which would under a permanent regime, seem optimal. Thus there may be a prolonged transitional period *after* the last grandfathers have departed, as the equilibrium fleet's distribution of vessel lengths, storage capacities, speed, weather-kindness, and gear types and combinations are phased in. Given the durability of vessels and the impracticality and danger of using them without strict maintenance, which also prolongs their service life, the "bang-bang" program prescribed by Clark and others may encompass more years than is usually realized.

There are many conceivable alternative discriminatory systems: entry can be rationed by race, color, creed, etc.; by bribery of officials; by queuing; and by lottery. The arbitrary expulsion of part-time and "sport" fishermen with low catches (in the opening stages of more elaborate schemes) should take a prize for high-handed, inefficient discrimination (Pearse 1971). Some of these do amount to an informal price or market system; but apart from emphasizing that all of them permanently inhibit participation by some specialists whose comparative advantage lies in fishing, the literature of fishing has had little to say about them.

In the earlier fisheries' literature, the influence of Pigou made it seem obvious that a tax on the catch or a fee on inputs was needed to equate marginal social and private costs. By the 1960s, however, consideration of the potentialities of the existing system of licenses (mostly for administrative information and revenue), and of the political drawbacks of introducing fisheries' taxes, had opened the literature to comparisons of the two systems. Existing administrative fisheries' licenses, like pollution permits, indeed made it possible to graft on either system: license fees could be increased until they rationed entry; or the number of licenses could be restricted (Sinclair 1960; Hamlisch 1962; Campbell et al. 1974).

Fee systems, however, seemed to have little hope of general political or constitutional acceptance. In some countries, the power or right to administer a charge high enough to ration entry to the right level would be considered as a right to levy an indirect tax, or perhaps an export tax. This power could not easily be delegated to a fisheries' administrative agency; it might instead be the prerogative of a different level of government; of a representative legislative assembly, not an appointed agency; and be subject furthermore to a crippling "uniformity of taxation" rule. On the other hand, the accepted power of government agencies to set or negotiate the financial aspects of oil leases and timber tenures did suggest that ways could also be found around these legal barriers to a price-rationing system, even though the resulting institution would appear to the lawyer closer to a system of property rights than of prices. The lawyer would be right, of course: it is difficult to distinguish the two systems analytically.

There was also scathing criticism (particularly from Crutchfield) of the political naivete of arguing for a higher fee to be imposed on low-income, under-employed participants in a depleted fishery. Even if in the long run no restricted-entry system could offer higher incomes than opportunity earnings, it at least ought to avoid beginning by squeezing out excessive workers by reducing them below the opportunity level. This argument, however, must meet the counterargument that in many countries fishing incomes are still high, and overfishing is not yet a problem; in these places fees or taxes would not come as a crushing burden.

Marketable fishing rights are no longer the academic panaceas that they seemed in the early 1960s. Authors then were forced to take their examples from the rights to pasture animals on public land, membership in partnerships or stock exchanges, and transferable quotas to deal in certain farm products, foreign exchange, or imported goods. These examples were not all helpful. In any case, they did not meet the fundamental objection that fishing was regarded by many as an essential civil liberty, not simply as free access to the public domain. In the course of persuasion, it became clearer to both audiences and exponents that "fishing rights" were not a unique instrument. They were a bundle that might have all or some of several characteristics: they might be *limited*; they might be *transferable*; they might convey *several* privileges and responsibilities; they might have a fixed *duration*; and they might be priced and so *marketable*. As time progressed, actual examples emerged, usually grafted on to existing license systems. Reviewed today, the early literature seems very unorganized and vague. The authors were struggling for a priori generalizations about license limitations among what gradually emerged as a near-infinity of combinations of the characteristics *underlined* above. As is so often the case with a novel proposal put forward under academic auspices, the authors seemed to have no sense of which side-effects of the scheme should be regarded as merely interesting, which as real or costly difficulties, which as insuperable political or constitutional constraints, and which as economically inconsistent or contradictory (see Scott, Crutchfield, Sinclair, Popper, and other contributors and commentators in Hamlisch 1962; Crutchfield 1961; Sinclair 1960; and Christy and Scott 1965).

As with earlier types of regulation, hesitation to adopt marketable rights stemmed from unknown and unresearched distributive questions. It was soon perceived that it would be just as difficult with rights as with taxes to devise a permanent payment scheme in which fishermen got some share of the rent. Scott had pointed to this difference between fishing and farming in 1955 and 1956, implying that only sole ownership would place fishermen, like farmers, in a position to share in the rent, or at least in changes in the rent, of resources. His 1962 paper on regulation returned to the same theme: if marketable rights were given away or auctioned, the rent would be captured either by the first holder (in a lump sum as the net present value of expected future harvests) or by the government. A fisherman's cooperative, once set up as sole owner for the entire stock, could guarantee its members a dividend that included the rent. But either the price of a membership in such a cooperative would rise so that only the original members obtained rent, or the membership would rise indefinitely, pushing the individual dividend toward zero, or at most the rate of normal profits. (The same would be true of a corporation.) Thus a property-rights system (like a tax system) offered no attractive distributive advantages over open access.

In recent years, this no-gain for fishermen argument has been set aside, if not denied, by writers who emphasized that the average income in a fishery included producers' rent (Copes 1970 and 1972; Turvey 1964). By this they have meant the differential returns to exceptional skill or endurance, relative to the marginal vessel or crew member. It is difficult to follow the arguments of some who have invoked this element in earnings; in some forms, it seems to me to be wrong. If I understand what is being argued, it is that producers' surpluses tend to be dissipated when there is open entry or crude regulation of the types reviewed in Parts II and III of this paper. But either a fee or a property-rights system (by restricting entry to those who, because they can earn the most producers' rent, can pay the highest fees or offer most for fishing rights) will allow such persons to get a greater surplus over their opportunity income. How are we to understand this argument? First, I may have misinterpreted it. Second, it may be that special skills are less useful under the restricted-entry (fee or rights) conditions; it may be, for example, that differential returns in the former situation are entirely explained, and entirely absorbed, by investment in capital intensity. But I do not believe these are the facts. Fisheries' experts repeatedly speak of durable groupings of skippers, vessels, and crews according to the size of their catch or earnings, year in and year out. The needed abilities are to find the fish, bring it in quickly, keep it in good condition, keep down crew size by cooperation and hard work, and land it and return to the grounds swiftly. These are certainly needed under open entry (with crude regulation); there appears no reason why the same abilities should not be valuable with or without regulation.

Third, it may be that under open access, the differential return does exist, but the average catch is so small even for the skilled fisherman that he gets a very small producers' rent. Under limited entry, however, the skilled fishermen would be free to expand their shares of the catch, and so their producers' rent. This amounts to arguing that the supply curve (Turvey and Copes) or the total-cost-of-harvesting-effort-curve (e.g. in Christy and Scott 1965) has a different intramarginal shape under open access than it has under closed entry. If this is so, it is possible that the differential going to a skilled fisherman is so much higher under the restriction system that, *after* taxes or the purchase of a property right, *average* incomes to *all* surviving fishermen are higher than under open access.

This third argument seems to be plausible, but only possible. The work of Pearse on the buyback scheme is relevant to the underlying problem of producers' rent and opportunity cost, as is the continuing statistical–economic–biological effort to agree on nonquestion-begging systems of measuring necessary effort (see both Pearse and Rothschild contributions to OECD 1972; Scott 1960).

A second source of hesitation, and of trial-and-error, has been the question whether to limit access to the fishery by restricting inputs or outputs. This question applies equally to fee systems and rights systems, and the actual problems were well forseen in the 1961–62 literature. In the environmental literature, the same question crops up as the problem of whether to tax (or subsidize) inputs into the water-pollution-creating process, or the output of pollutant. Consequently, little need be said. Pearse's 1971 paper, Munro's report of 1977, and doubtless many official reports have kept the British Columbia buyback experiment before the professional eye. (For a recent survey see McKellar 1977.)

The theory is simple enough. If profit is to be made by exploiting some production function in which input characteristics are substitutable, then restricted access or high price of one input or characteristic will cause the entrepreneur to use more of others. Thus if a tax or restriction is placed on the number of vessels, it will pay to design vessels larger, faster, or more labor- or gear-intensive. This substitution, weakening the attainment of the original purpose of the restriction, will then induce the authorities to increase the tax or to tax or restrict another feature, such as number of tons, length, or some weighted index of vessel effort characteristics. All such formulae must induce costly adjustments, both in terms of the extra investment to make the most of the narrow design restrictions, and in terms of the extra amount of other inputs employed to make up for its deficiencies. B. Campbell, Pearse, and Munro suggest that official studies have shown that in spite of the retirement of many vessels, the amount of capital (in deflated dollar units) is now greater than before license limitation and buyback began. This need not be the case, of course; it should not be assumed that input restrictions must invariably produce unacceptably high costs.

Such observations have led to a new interest in restricting the catch. One method, proposed by Jamieson (1958) and many others in the 1960s, was to restrict the output of the harvesting process, instead of the inputs. In countries where the fish were priced by prior agreement between buyers and sellers (represented by associations and unions), or where the crew was paid in a share of the gross proceeds of the trip, the sales slip at the dock became a standardized, accepted document. At this point it was possible to measure the size and composition of each vessel's catch (other details were often included, such as time and place of catch) (see Crutchfield 1955; Gerhardsen, Zoetweij, and others in Turvey and Wiseman 1957, and Rothschild and other participants in OECD 1972).

In these countries at least catch was measured and described, and so was available as a unit for restriction. Either a tax on landings or a fixed catch-quota per input unit would do. Elements of both systems are mentioned in the literature in the late 1950s and by the time of Crutchfield and Zellner 1961, Royce et al. 1963, Crutchfield 1961 and Scott 1962 were becoming commonplace.

Furthermore, it was seen at once, both for a stationary harvesting model and for dynamic models, that at a sufficiently high level of abstraction, the systems were identical. In the stationary model, one could indifferently price the fish (fee) and let the market decide on the catch, or set the total and individual quota, and let the market determine the value and the fees. The same was true for a dynamic model, *except* that both fees and the number of fish in an individual quota (or the number of quotas) would have to change as the model moved toward some stationary or level or time-path.

It was seen that this system could well be tied in with the *national* quotas being set for an expanding number of international fishing conservation conventions. If each nation were to be given (or sold) the right to catch a given number and quality of fish, would it not be easiest to break this down into regional, and then into vessel quotas? Indeed, could not an international trade in quotas emerge, not only between the national authorities but also between the individual vessels? (See Christy and Scott 1965; see also the subsequent 1966–68 debates at the Rhode Island Law of the Sea meetings; Christy 1973a, b.)

Thus began a general inclination away from restricting vessels or fishermen, in favor of restricting total catch by taxation or quotas. But any illusion about the seeming simplicity of this approach is soon shattered by realizing that output is not a unique product, but usually consists of a number of products. As foreshadowed earlier, the problems (and decisions that must be made) about this jointness can be classified as follows: (1) the catch from one stock usually consists of fish of several ages, sizes, and qualities; (2) the catch from one place may contain fish of more than one stock; and (3) more than one species; (4) the catch landed at one place is caught in more than one place; and (5) all can be caught in more than one season or year.

These five complexities mean that, strictly speaking, any scheme of preventing excessive entry by rationing the right to take fish can achieve efficiency in the allocation of inputs among outputs (that is, bring about equalities of marginal rates of substitution of inputs and outputs with their respective prices) only if it assigns prices (fees) to each fish caught according to its age, stock, species, place, and time; or, alternatively, if it distributes separate marketable rights for each of these. Furthermore, because fishing has the public-goods "externality" of reducing the density of its own stock and thus reducing finding and catching costs, but increasing congestion costs, these prices or rights should not be fixed, but should vary with each stock's density. Finally, because there are ecological interdependencies between the rates of growth and the spatial migrations of the various stocks and species, the prices or rights should vary with the damages the catching of fish from each stock imposes on the future availability of other stocks.

While this list of conditions for a perfect economic system of controlling the catch is not always as daunting as it seems, its complexities do reduce the apparent superiority or regulating catch over restricting inputs. The technology does not exist, as yet, for allowing fishermen to adjust to fishing fees or rights by substitution among stocks and species in one place, so that joint capture must remain the rule. But technology and capacity does exist for fishermen to choose the size, place, and time of catching fish. It follows that either (1) prices (fees) must be set for each of these characteristics of output, (2) quotas assigned to particular fishermen with specific stipulations about each characteristic, or (3) general regulations must be made about the permitted catch of all fishermen to be divided among sizes, places, and times. All these modifications are possible, although the information requirements of the specific pricing or quota alternatives seem *very* high.

Such considerations reinforce what I discern to be general tendencies both to move towards the control of outputs (catch) rather than inputs (vessels and gear), and to use property rights or taxes. In the following pages, we shall attempt a more formal comparison of the two methods of restricting output. The reader should bear in mind that, as has already been recognized, at the level of formal analysis, price restriction is the dual of quantity restriction. If there were no "difficulties" about information and transactions costs, and no other aim but efficiency, there would be no reason for preferring either. To suggests where theory should go now, therefore, we must continue in this paper to remain suspended between the pure theory of the single fish stock and the ragbag of technical administrative and political difficulties that confront actual fisheries' management agencies.

V. Property Rights in the Catch (Quotas)

The main approach of this section will be to explore under eight main headings the theory of fishing rights (quotas) by comparing them with taxes. In the previous section it was recognized that, at the level of abstract stationary or dynamic theory, the two systems are equivalent. Three important omissions must be mentioned first.

The first omission is the use of subsidies. A fisherman or vessel could be bribed *not* to catch a fish, instead of being charged for catching it. Furthermore, he could be presumed to have a property right in catching fish, and be bribed to sell it. As Coase and others have shown, it often does not matter which of these two techniques is chosen in dealing with a spillover or other transaction between two parties. However, in the case of the fishery, there are also public-good effects (stock effects) to worry about; and there are problems about deciding whether potential fishermen, who demand a bribe, are serious potential entrants. To avoid prolonged analysis of these problems (which may be soluable) bribes (negative fees) will not be discussed. In the real world, fishermen are bribed to *enter* the fishery, not to leave it, by vessel subsidies, tax concessions, and unemployment insurance. These measures offset the entry-restriction measure to be discussed here; they are presumably to be justified on distributional grounds. We will not discuss them further.

The second omission is distributional, having to do with public revenue. Fisheries are part of the public domain ("the common heritage of mankind," in the L.O.S. formulation). Thus it seems to many people that fishermen ought not to make money without sharing the rent with the public. This way of looking at the matter can lead to the amount of revenue becoming the criterion for the choice between entry-restrictions systems: tax revenue versus price revenue. Economists are often disconcerted at this reappearance of the distributional aspects of policy choice into what they had pared down to an allocational issue. (Other examples are the surprising prevalence of politicians to regard the protective tariff, and the pollution tax, either as promising sources of revenue — which indeed they may be — or as a public claim that ought to be acknowledged even if it is unremunerative. See Campbell 1976; Fox and Swainson 1975; Australia, I.A.C., 1977, p. 34.)

We shall say little about revenue here, acknowledging that if it is an important goal, some systems of licensing must be rejected. In almost every country today, unregulated fisheries are a drain on the economy's production possibilities; furthermore, they are a drain on the public purse. That this situation continues suggests that revenue production does not yet rank high among public goals for fishery regulations.

The third omission concerns alternative, dynamic, objectives. In the literature it is usually assumed that restrictions are to be used to change the size of the fleet and *hold it in a steady state*. Thus in the absence of random perturbations, the annual catch is to be guided along a chosen path until the stock and the catch reach the desired level. It follows that the transitional tax or level of rights may differ from the final rate or level. Furthermore, the new interest in pulse or cyclic fishing, and the possibilities of a demand for a gradually rising or falling trend, responding to external changes in factor supply, substitutes, preferences (and so on) all suggest that gradually changing tax rates, or rights, may be in order. Finally, "flexibility" of rates and rights may be sought for special reasons, varying from changing attitudes to revenue to the expected need to make room for other uses of the ocean or for foreign fishermen. In this section, I cannot deal with the proliferation of types of tax and right that would have the right degree of flexibility to be acceptable to fishermen on the one hand and cyclic or spiral on the other. Instead, I will discuss institutions designed to produce the correct steady amount of effort, recognizing the likelihood that information is often wrong, technology changes, ocean currents and climate shift, and demands rise and fall. How a fishery approaches this fixed (stochastic) level is too complicated a question for this survey.

In this comparison of fishing quotas with fees or taxes, we have in mind the following systems.

The tax system would consist of a charge, levied at the landing place, on each fish. The complications of age, stock, species, place and time, and of interdependencies and of stock externalities already mentioned, might be handled by having a different rate of tax for fish of each characteristic, variable with respect to the rate of depletion of the stock, and with respect to the impact of the catch on other stocks. Alternatively, supplementary regulations and controls could govern these problems. Assuming that the aim is to hold the stock and catch at a certain (stochastic) level, the basic tax would, in equilibrium, be at a fixed, proportional rate per unit of catch. So far as I know, no regulatory tax or royalty on the catch is anywhere in effect today.

The quota system would look a little like some present restricted rights or license systems, except that a quota would not convey the privilege of going fishing, nor of using a vessel; it would permit the holder to land a certain number of fish. Quotas would be transferable, marketable, and of fixed duration. As with the tax system, the complications of age, stock, species, place and time, interdependency and stock externalities might in part be dealt with by special individual quotas for fish of each characteristic and in part by general laws about the conditions under which all rights were valid.

How are these rights to be distributed and redistributed? We have already discussed a "grandfather system" to approach the desired number of participants. Another, perhaps better, system is to give every active fiserman a quota certificate; however, the size of the catch going with each quota may be very small; and fishermen will be given an incentive to buy and sell quotas to assemble rights sufficient to catch a profitable amount (Australia 1977, p. 35).

Both these systems make the quotas a free gift to the original holders. Other important alternatives are that they be initially free but taxable (not as a royalty, but as a capital asset); that they be repurchased, repossessed, or periodically reauctioned; and that they be redistributed by lottery (Scott 1962; Crutchfield 1961). (Furthermore, they could be used for positive redistributive purposes, such as guaranteeing a livelihood to isolated communities, or to protected groups.)

None of these distributive aspects affects the working of the quota system, so long as quotas are transferable, marketable, and of fixed duration. Any holder's behavior during the life of his quota should be independent of how he acquired it.

There is a literature on quotas, much of it unpublished papers that deal with managing extended fishing zones. (Anderson 1977 is a good example of published work.) However, seen from a distance, little of an analytic nature has been written since the 1960s (Hamlisch 1962), except concerning international waters (Christy and Scott 1965 inspired a number of L.O.S. contributions, many of them in the legal literature. See, however, Crutchfield 1966, Crutchfield and Pontecorvo 1969; Pearse 1971, Christy 1973, Scott and Southey 1970, and Tussing 1971. The extensive literature proposing or analyzing pollution property rights is essentially untapped by fisheries economists, although it is by now mostly common currency among environmental economists. Readers would gain by reexamining Ackerman 1977, Scott and Branson 1972, Dales 1968, and Tietenburg 1974 and subsequent papers.) I now commence the examination of the quota system, under eight headings.

a) *Directness:* For an overfished stock, taxes would work through their discentive effect. At a certain tax rate, stock effects would increase fishing costs until the taxed fish was no longer valuable enough to justify continuing fishing. Taking into account the fixed costs of vessels and gear, the tax would make fishing completely unprofitable for some fishermen, and potential fishermen.

Whether the tax rate struck was correct, however, would be a matter for trial and error. As with charges on pollution, it is difficult to predict how much fishing will persist, in the short run and in the long run, at a given rate, and whether this will bring the catch and stock to their target levels. A new rate may have to be tried. The resulting uncertainty about the permanence of any rate would be a disadvantage of the system in itself, quite aside from the waste of time in over- or under-fishing at the wrong tax rates.

I believe that a quota or property-right system would have less of this uncertainty about fisherman response. When it has been decided how large the catch (for the relevant period) is to be, pro-rata shares will be assigned to each fisherman quota. He *knows*, for that period, how many fish he can catch. If it were not for stock effects, furthermore, he could choose his own pace of bringing in his quota. Even with stock effects, he need not race for the catch to the same extent as a taxed fisherman must. It follows that the catch will be more spread out over the season, to suit the preferences of the fisherman and of the market.

b) *Stock and catch uncertainty:* Of course, even when the amount that may be taken by each fisherman is determined and announced, it may turn out that the official calculations were wrong. There may be, say, fewer fish available than when the tax rate of individual quota were set. In these circumstances, the authorities must change the tax rate per fish under the first system, and the allowable catch per individual quota under the second.

The tax system, depending on a predictable relationship between the after-tax value of fish and the amount of effort expended by the fleet, is probably capable of bringing about the desired direction in change in effort. But, with many participants, it may be affected by lags, and by too much variety in individual responses, to achieve precision in the change; short-run over- or under-reactions are therefore to be expected. Furthermore, unexpected changes in tax rates may create fisherman expectations of further changes, in either direction, thus aggravating tendencies to over- or under-react.

The quota system is more precise in this respect. A change in the number of any kind of fish that may be taken with a unit quota can be quickly signalled to all quota holders. With experience, the authorities should be able to bring about precisely the desired change in catch. Expectations are a problem here too, however. If fishermen expect that the catch-value of their quota is likely to be reduced, they will tend to accelerate their catching effort. (It does not appear that an expected increase in the value of the quota would have a symmetrical decelerating effect. Good discussions of uncertainty with water licenses and rights are to be found in Roberts 1975, Roberts and Spence 1974, and Fox and Swainson 1975).

c) *Progressivity:* Economists who write about fisheries are very tense about the rate of innovation. Laymen and politicians often believe that fishermen are unduly conservative, reluctant to adopt new techniques. This observation is reinforced when subsidies on new equipment, or the working of the crew share system, is biassed toward traditional methods. Furthermore, unprogressive fishermen may have obtained protective regulations that prevent the introduction of new techniques.

Such evidence is not convincing. Many fishermen, like farmers, obtain pleasure from planning and acquiring ever more elaborate vessels, gear and communications. Furthermore, Scott and others have argued that the race for fish (in the many-fishermen case) encourages too-rapid innovation in techniques that allow a fisherman to intercept or anticipate his rivals (1962). This tendency may not be serious. In general, as long as vessels race for the fish, neither a tax system nor a quota system will prevent lop-sided over-investment in speed and capacity. Only sole ownership can do this.

d) *Interception: Allocation of fishing within the season:* As Christy and Scott (1965) bring out, a system of national catch quotas fails to remove one costly aspect of unregulated fishing. I refer to the tendency, as over-fishing becomes more serious, for fishermen to capture a good share of the available catch by intercepting and capturing the fish before their rivals. This leads (spatially) to pushing effort out to sea into the path of migratory fish, and (seasonally) to advancing effort into winter months or earlier weeks than usual. The result is more remote, dangerous and costly fishing, more concentrated marketing, and lower quality of the product.

Both tax and quota systems can deal with this problem. The tax rate can be progressive with respect to the place, time, or aggregative rate of fish landings, or some combinations of these. Quotas can be located and dated to discourage excessive fishing under high-cost, high-concentration conditions.

Either of these modifications would have high administrative costs. Costs could be avoided by a system of dispatching individual vessels, or by simply closing the fishery in certain seasons and places. Dispatching usually, but need not, involve sole ownership or queuing as taxicab dispatching shows (see Loose 1978).

e) *Divisibility:* We turn to two closely associated characteristics of the two systems: divisibility and complexity of the units under control.

Little need be said about tax divisibility: taxes can be levied on individual fish, tons, or boat loads. There is a danger that catch quotas may, for administrative purposes, be in larger units. Such indivisibility can be costly. Pearse (1971) writing about input restrictions has shown this convincingly. When (vessel) fishing rights are indivisible, potential fishermen with relatively low catching ability but also relatively low opportunity costs, are unable to enter sufficiently high bids for licenses for whole vessels even though they could bid more *per fish* than the successful highliners. Thus they are shouldered out because the unit for which they bid is bigger than they need. The answer is obviously to permit them to bid for smaller units. If this can be done with catch quotas, taxes and quotas would be equally successful in allocating those with a comparative advantage in fishing to the industry.

In my opinion, the same comment applies to well-know allied work on pollution by Buchanan and Tullock (1975). They prefer a pollution tax to a pollution license when the overall policy is to reduce industry output. They argue that an appropriate tax allows all firms remaining to adjust to optimum scale on their long-run cost curves, whereas pollution licenses leave too many firms operating at a scale less than optimum. This criticism of licenses, however, is valid only if they are indivisible. If they can be subdivided and marketed, their effect on industry behavior should be the same as that of a tax (Buchanan and Tullock 1975).

f) *Complexity:* I have said, several times, that because the typical fleet is composed of a variety of vessel sizes using a variety of gear, and because it is searching for fish from a variety of stocks and places, there is great difficulty in deciding on a single unit of entry restriction.

In the existing B.C. *vessel*-restriction system (Pearse 1972) as with that described by Crutchfield and Pontecorvo (1969, p. 178–80), it is recommended that aggregate fleet fishing power be kept constant by making licenses applicable among various sizes and types of vessel in proportion to their respective officially accepted fishing power. This recommendation is analogous to a recommendation for transferable pollution effluent permits: each should be useful for alternative set *equi-damage* rates of waste disposal of the respective waste substances, thus allowing the holder of a permit to flexibly change location or industrial process and so the damage from his effluent (Dales 1968; Scott 1972). In fishing, similar fixed-ratio systems can be used either for tax systems, with factors to lower or raise tax rates according to species, place, and time of landings, or for quota systems, with factors to convert fish harvested from various species, places, or periods to set fractions of the standard quota.

But such factors or ratios are extremely difficult to set, and change rapidly over time as knowledge accumulates and conditions change. In spite of the extra paperwork involved, it would probably be better to assign each vessel a packet of rights, one for each species, stock, place, and time. These would be exchangeable, so fishermen could specialize. They would also tend to discourage inadvertent joint catching of stocks, by forcing a fisherman to acquire from other vessels (for money, or in exchange), rights for fish not sought or wanted. In a fleet with many participants, each type of right would acquire its own market value. The authorities, by "open market operations," (buying in or selling extra particular rights) could guide the fleet away from overfished stocks or places and into underutilised fisheries with rather more enforcement costs. A tax system could work the same way.

The information and enforcement costs of either of these detailed systems, in a complex fishery, would be very high. In both, the basic source of information would be fishermen's own declarations about the source and nature of their catch. Checking up on these statements would be difficult and costly. Unlike more primitive systems (such as closed areas or closed seasons), "self-enforcement," by vessels keeping an eye on each other, might not work well. This is because each vessel, under a pure tax or a pure quota system could choose freely when and where to fish, so long as each paid the appropriate fee or used the appropriate part of its total quota for fish taken from an area with a small aggregate, total-fleet, permitted harvest. Thus the tendency of others to jealously prevent a vessel poaching or contravening other regulations, is weakened when tax and quota systems allow any given vessel to do anything, if it is willing to pay the price.

For less complex fisheries, the number of types of license, or fee, might be quite small. Meany (1977) suggests that in many fisheries each species, if not each stock within that species, would need its own specialized gear. He recommends a different fee for each gear, thus in effect also recommending an easily enforceable fee for each stock, species, or place. This suggestion also applies to quotas/rights.

However, for very large (and international) fleets, the administrative costs of multiregion, multipurpose, multispecies catch or vessel licensing would be severe. It is probable that a system that set out to bring about efficiency in the allocation of labor and capital to fishing many species, and places, with one or more fleets, would attempt to reduce the costliness of administering and enforcing one-right-per-vessel-for-each-stock-and-place systems (or their equivalent tax systems) by removing some economic choices from fishermen and replacing them with blanket, enforceable, prohibitions or controls.

To conclude the tax–quota choice, a complex fishery is bound to induce high transactions (information and enforcement) costs under either system of regulation. Considering that specific quotas would have to be produced at the dock to permit the sale of each type of fish, and that the market in specific quotas would keep their specificity in the public eye, I am inclined to argue that the enforcement and compliance costs of quotas would be somewhat less than for a system of specific taxes for each stock, species, and place (Eckert 1973). Under the tax system, there would always be a temptation for the vessel to claim that all its catch came from one or a few specific categories. This would be impossible for a vessel that, during a year, relied on all its subquotas.

g) *Joint action, collusion, and interest groups:* Support or opposition to rights or warrant systems in fisheries frequently arise from beliefs that instead of the flexibility and versatility of individually held quotas, the sector would wind up with the inflexibility of corporate, oligopolistic, or union-held blocks of quotas. This concentration or combination is certainly a possibility, perhaps more probable with a system of rights than with taxes.

The general purpose would be to reduce the number of participants, vessels, owners, or fishermen. This would allow those who had purchased or combined rights to exact some control over the fishery additional to those administered officially.

In negotiating the price of fish, such combination in the hands of the companies (for the unions) would give them extra bargaining strength, although this strength would not necessarily be greater than that now held by fishing associations or unions. These possibilities have affected attitudes to limited fishing quotas by focusing attention on their potentiality for upsetting a known set of institutions, rather than on their specific merits.

A second application of the power of concerted action would be for groups to acquire blocks of quotas for their own use (as with the officially protected groups mentioned in Part II — here the protected holders might be native Indians, or old-age pensioners). Such acquisitions could be at public expense, for redistributive purposes. Alternatively, self-appointed groups could acquire licenses to promote other activities by *preventing* fishing. For example, they might, holding quotas, wish to augment or reinforce official efforts at fish or mammalian conservation, reduce permanently a stock they disliked or feared, obtain for themselves more stock and elbowroom for water sport or sportfishing (compare Dales 1968), use the waters for waste-dumping or land fill, thus killing the fish for which they held quotas; or reduce the presence of commercial fishermen in certain places (oil fields, hazardous navigational narrows, or holiday areas).

Because of the public-goods aspects of fisheries, it is unprofitable for a single person to acquire rights for any of these purposes that affect the whole fleet: joint action is needed by associations or firms. The work of M. Olsen gives clues to the benefits and costs of forming joint or collusive clubs or associations (1965). The more specific each quota or right, however, regarding to species, place, or time, the less is the need for joint action. On the other hand, if an outsider merely wishes to catch a certain number of fish, he has merely to buy a quota; joint action is not required unless there are economies of scale in sportfishing (congestion, provision of marinas, selection of certain subspecies for preservation).

h) *Flexibility:* It is frequently said that one of the worst flaws in most resource-management systems is their inflexibility. P. H. Pearse in his Royal Commission Report on British Columbia's forest policy has strongly criticized this characteristic, and the same theme is to be found in Campbell et al. on water policy in Ontario (1974) and other studies to which he has contributed. A system of rules, or system of tenure, that prevents smooth adjustment to exogenous changes is likely increasingly to waste natural resources, labor, and capital, and to distribute rents and earnings away from the Crown and others who originally shared in the bounty of nature.

But flexibility is a dangerous characteristic in a policy or social institution. Like individual voters and organized pressure groups in political life, members of the fishing industry will not stand passively by while government administers a flexible scheme for restricting entry. Instead, it can form its own political pressure groups and coalitions, attempting to obtain a policy that meets their demands. The more "flexible" a policy, the more it will attract political action (and indeed social movements) to change it. Furthermore, flexibility also invites less savoury attempts to overcome an unfavorable policy: excluded or injured industry members can try bribery and corruption to buy their way into the industry, as individuals or as groups. Clearly, every person has three investment choices: he can buy the rights he needs (or pay the equivalent tax); he can signal politically for a change of general policy; or he can pay individual legislators or bureaucrats to change a policy, or at least to change its application to him. No matter how much he may believe in the rule of law, the second type of investment will seem just as moral as the first; and the third, in extreme conditions, may promise an attractively high yield relative to the first pair. If such should be the fate of the system, it would obviously both destroy the legitimacy of the regulatory system and create dangerous cost-increasing uncertainty among vessel owners.

With these possibilities, for the typical fishery, I favor a system of property rights rather than a fiscal device such as tax or subsidy. I have two reasons for this.

In the first place, to sell or give or give a marketable quota to a fisherman is to associate it in politicians' and citizens' minds with other rights, privileges, obligations, and instruments issued by the government: annuities, bonds, and titles, and currency for example. All enter their owners' portfolios of explicit, formal, negotiable assets. Thus the temptation to attack the system for personal gain, through political or corrupt activities, should be moderated by general legal and juridicial attitudes in our society that tend to preserve the integrity of the government's individual undertakings and to resist proposals that they be regarded as subject to the same changeability as, say, the rate of property tax, income tax, royalty rate, or public insurance premium. Such solidity, integrity, and certainty is highly valuable in a system in which a large number of fisheries will be regulated by public servants under delegated powers (Buchanan and Tullock 1975; Chisholm 1978).

In the second place, a measure of allocational flexibility is, nevertheless, possible by government "open-market operations" including a buyback policy of quotas and similar market operations to change the relative value of the special privileges or prohibitions that apply to particular species, times, places, etc. If regulators were in general to use such market operations more, and uncertainty-creating, arbitrary changes in controls and prohibitions less, the willingness to comply with the revealed policies would increase. (As Scott and Southey 1970 and Crutchfield 1961 argued, it would be very costly to run a fishery on individual property rights alone. Coase disagreed with this. But some supplementary controls do seem less costly than either full internalization [sole ownership] or a finely tuned complex of individual quotas, with every characteristic marketable.)

Admittedly, this "open-market operations" policy does prevent a flexible change in the share of the public in the rent of fisheries. But my own preferences are not to strive for a system that captures rent directly for the Crown, but for a system that allows rent (net present value) to exist at all. In any case, as various commentators have reminded me, it is possible to tax a fishing right as an asset, the rate of this tax being a matter for political decision. I have some fears that frequent changes in this rate would lead to tax-avoidance behavior that, in some fisheries, could be deleterious, for example, a subquota tax can be changed. Thus the quota alternative does not require that public revenues be abandoned, or unchanging. (I do fear that if every subquota, described above, were subject to a changeable wealth or property tax, having income effects, evasive or socially wasteful behavior might result. But careful model-building and empirical research is needed to elucidate this question.) As with pollution rights, so with fishing quotas, there is no need to regard tax or fee method of entry restriction as uniquely suited to distributing much of the rent to the public.

Examination of my discussion under all eight of the headings above will suggest my own final preference for a rights system. It is perfectly true that, as abstract theory would insist, a tax on the catch, and a property-rights system can work in similar fashion. Whatever one can do, for efficiency, equity, and conservation, the other can be made to do. What then should be the final basis for choice?

The final choice should be based on the minimization of transaction and administration costs. The survey has shown that both systems can achieve the same ends; therefore the only difference between them is the "difficulty" of obtaining information under one system or the other; fuller examination of this problem suggests that we are talking about the inputs needed for information about the fishery and about the fleet, for decision-making in the interests of efficiency and equity, and for enforcement, monitoring, and feedback. Economics tells us that all these activities have costs, and that we may in fact compare the two systems by comparing the costs of using them (not, to repeat, the costs of fishing, which can be the same under either system).

The editors would not want me to commence a comparison of the levels of these costs, under the eight headings, for the two systems. In any case, we need facts and not opinions. So I will conclude with a hypothesis, which I have formed by reexamining the eight main criteria in this Section: the total costs of administration, transactions, marketing, information, and compliance (and of evasive behavior as well) would be lower under a quota or rights system than under a tax system that achieves the same present value (net of such costs). Both systems would be very costly techniques for dealing with some regulatory important details of fishery management. In these respects, they ought to be supplemented with blunt, crude, controls of timing, spacing, place, and so forth. When this has been done (when each system is "optimized") I would predict that one based on quotas would have lower overall transaction and administration costs than a fee (or royalty) system.

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Economic and Social Implications of the Main Policy Alternatives for Controlling Fishing Effort[1]

J. A. CRUTCHFIELD

Department of Economics, University of Washington, Seattle, WA 98195, USA

CRUTCHFIELD, J. A. 1979. Economic and social implications of the main policy alternatives for controlling fishing effort. J. Fish. Res. Board Can. 36: 742–752.

Discussion of the need for economic rationalization has led to increasing interest in alternative strategies to control fishing effort in efficient ways. Three basic alternatives are considered: taxation, control of fishing inputs ("limited entry"), and direct limitation of output through individual fisherman quotas. Each is analyzed in terms of specified elements of economic efficiency, distribution effects, freedom to choose fishing methods and strategies, and administrative feasibility. It is noted that in practice all would be used in combination with other direct measures to assure flexible control over fishing mortality. A number of common objections to economic rationalization of open access fisheries (e.g. creation of monopoly power, unemployment, failure to reduce consumer prices, and nonmonetary values associated with fishing) are analyzed and rejected as largely invalid. While the inherent short-term instability of commercial fishing and data problems preclude any "maximizing" model of a rationalized fishery, the prospects for workable programs leading to improved economic performance without adverse societal impacts are excellent.

Key words: fishery economics, taxation, limited entry, quotas, open access fishery, sociological aspects

CRUTCHFIELD, J. A. 1979. Economic and social implications of the main policy alternatives for controlling fishing effort. J. Fish. Res. Board Can. 36: 742–752.

L'analyse du besoin d'une rationalisation économique eut pour effet de susciter un intérêt accru à l'endroit de stratégies visant à contrôler l'effort de pêche par des moyens efficaces. Trois options fondamentales sont considérées: taxation, contrôle des entrées et limitation directe des sorties par le biais de contingentements de pêcheurs individuels. Nous analysons chacune de ces options en fonction d'éléments spécifiques d'efficacité économique, effets de distribution, liberté de choisir méthodes et stratégies de pêche et possibilité administrative. On fait remarquer que, dans la pratique, toutes ces options seraient combinées avec d'autres mesures directes visant à assurer un contrôle souple de la mortalité due à la pêche. Nous analysons et rejetons comme invalides, pour la plupart, un certain nombre d'objections communément soulevées à l'endroit de la rationalisation économique de pêcheries dont l'accès est libre (e.g. création de monopoles, chômage, impuissance à réduire les prix au consommateur et valeurs non monétaires associées à la pêche). L'instabilité à court terme inhérente à la pêche commerciale et les problèmes relatifs aux données ne permettent pas de construire de modèle d'une pêcherie rationalisée à rendement maximal. Mais quand même, on a bon espoir de pouvoir élaborer des programmes pratiques qui amélioreront le rendement économique sans effets nuisibles sur la société.

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AT this stage of the game it should not be necessary to justify the position that an open access fishery will produce unsatisfactory time rates of use of the resource. "Unsatisfactory" covers a multitude of ills ranging from modestly excessive use of labor and capital inputs to total extinction of fish populations. Both theory and a long series of empirical studies lead to the following unpalatable but firm conclusions. Excessive quantities of capital and labor will enter the fishery, and overcapacity will worsen as real prices rise. Biological depletion will usually occur unless fishing mortality is curtailed by measures that raise costs of fishing. The costs of management, research, and enforcement will fall on the general taxpayer.

Actual performance is often considerably worse, since these outcomes rest on a static formulation with a zero-cost adjustment mechanism. In real fisheries the physical functions linking yield and effort are highly unstable, for reasons rooted in the complex environment of the sea which are poorly understood and rarely quantifiable at acceptable cost. Coupled with this yo-yo model of physical availability is an exaggerated degree

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of asymmetry between entry and exit in an unrestricted fishery. While it may take considerable time to become a skilled fisherman, neither human nor physical capital requirements for a viable unit are high. Hence every "big year" — whether in terms of abundance of fish, high prices, or both — produces a burst of new construction and entry. But declines in incomes in poor years do not produce an equivalent reduction in capacity. Factor mobility in any industry is rarely that responsive, and the sociocultural setting of fishing communities makes them even more sluggish in reacting to low incomes. Also, the nearly universal share system makes the supplier of labor a coventurer in the fishing enterprise and levels out the effects of price or catch fluctuations on returns to capital. The inherent instability of the biological determinants of short-run input–output functions and the typical producer response, biased toward an excess of entry over exit, produce returns to both labor and capital that are more often below than at or above opportunity levels.

Clearly society could reasonably expect better performance from the industries utilizing living resources of the sea. In the most general terms rationalization means the "reallocation of resources . . . under open access to a controlled system designed to maximize the net value of production from the economy as a whole" (Anderson 1977). From the standpoint of economy-wide efficiency the following specific elements emerge:

1. The right level of catch — at which the marginal social value of the harvest is equated to the incremental social cost required to take it (including management costs).
2. The right size (age) composition of catch. No net economic gains can be obtained by allowing smaller fish to grow (i.e. where marginal increments to revenue from growth are just offset by marginal losses to natural mortality and costs of program implementation).
3. The right number and configuration of vessel–gear–fishermen units to minimize the aggregate real cost of taking any given catch (i.e. optimal factor combinations) .
4. Optimal fleet deployment; no increase in yield and/or reduction in cost can be achieved by altering the area or time fished.

Management measures that increase net economic returns in any or all directions are regarded as steps toward rationalization.

But economic efficiency alone is not enough; the literature on natural resource management is full to overflowing with warnings about the multiple objective problem. Economic rationalization of fisheries will usually be constrained by conflicts with other social objectives. These constraints warrant special consideration since, though legitimate, they have so often been perverted into cleverly concealed arguments for the maintenance of the status quo and the peaceful life of an unharried government decision-maker (Crutchfield 1973).

Two basic assumptions of fact underly the discussion that follows. First, it is assumed that real prices of fish will increase over time (particularly in the fisheries regarded as prime candidates for gear reduction programs). The potential gains from rationalization will therefore continue to grow even where physical production cannot be expanded further. Second, it is assumed that management designed to achieve more rational use of inputs will be dealing with fisheries already overcapitalized and subject to all the ills of open access. There simply aren't enough "new" fisheries on the horizon to bother with the easier question of developing a rational harvesting and management program from the outset. (Antarctic krill and blue whiting are notable exceptions, but it is difficult to identify many others.) Moreover, public acceptance of the need for fishery management of any kind rarely precedes serious overfishing, and this is likely to be even more of an obstacle when nontraditional measures are proposed.

It is abundantly clear, from theory and experience, that no management program that does not include control over inputs to fishing (or induce fishermen to do so) can offer much lasting improvement in economic performance over open access (see Crutchfield in 1961, Scott 1962, and Anderson 1977 for examples.) Thus any discussion of the economic aspects of rationalization must focus on means of reducing total inputs for any given catch level and on the extent to which least-cost combinations of inputs can be encouraged. This rapidly reduces to three measures: taxes or fees; direct limitation of numbers of fishing units, achieved by licensing boats, fishermen or both; and, at the hypothetical level, the establishment of rights to specific quantities of fish for individual operators. As indicated in the following discussion, it is misleading to categorize them so neatly, since it is argued that combinations of two or more make better sense than any one alone.

It is taken for granted that these measures to rationalize fishing would be backed up by necessary authority to take fast, direct action to deal with emergency situations in the environment. Fluctuations in natural abundance, seasonal availability, and concentration are inherent characteristics of marine fishery resources, and forecasting capabilities are inherently limited. Rationalization measures are therefore regarded as the backbone of management programs designed to improve economic benefits, but short-term flexibility must come from the power to cut off fishing by time, area, or species when developing evidence of trouble requires quick action.

Before turning to the alternatives that promise improved economic performance, a word of caution about data is in order. In evaluating alternative methods for rationalizing marine fishing, the technical difficulty and cost of accumulating necessary information on a timely basis must be weighed very carefully. The more elegant formulations of fishery management in a dynamic framework of optimal control theory (e.g. Brown 1974; Clark 1977a, b) assume a level of information on a forecast basis which is not only unavailable at present but almost certainly will be unavailable at any conceivable cost in the future.

Apart from the technical problems of interpretation of CPUE data, and of problems associated with other estimating techniques such as cohort analysis, the fishery manager deals with lag problems that would make Professor Friedman cringe. For all practical purposes, he uses last year's data this year to prepare management plans for next year's fishery. A 2-year lag in data is simply unacceptable for refined management techniques, and in the case of pelagic and anadromous species that are peculiarly susceptible to serious depletion with even a single year's overfishing.

The Role of Taxes[2]

Taxes play a dual role in the formulation of an integrated program to rationalize overcapitalized fisheries. The two are not inherently incompatible, but in the pursuit of one it is quite possible to lose some of the benefits to be achieved from the other — hence the necessity of distinguishing them clearly. The first is the use of taxes as a means of offsetting any adverse effects on the distribution of wealth, income, or employment, as a result of an otherwise efficient management regime. Tax incidence is a tricky area of economic analysis, and the tendency to regard taxes and transfers as a simple way of redressing undesirable income inequality is seriously misleading. Nevertheless, it remains true that a highly successful limited entry program unaccompanied by any tax measure to capture a portion of the economic rent created may produce transfers of income and wealth in a direction that would be unacceptable to most people. With due acknowledgment of the philosophical nature of judgments about the goodness or badness of income distributions, management measures that confer substantial gains on groups of private enterprisers and their employees at the expense of the general taxpayer are not considered good form. A major advantage of a tax on remaining participants in an efficient fishery would be the ease with which it could be used to convert the social costs of management to an explicit charge on the productive activity that gives rise to them.

The second use of taxes in a rationalization program is to influence both the level and composition of effort directed at a particular stock. As suggested initially by Scott, and developed in considerable detail by Smith (1969) and others, taxes can be devised that will convert the several types of externality that plague an open access fishery into contractual costs to the individual decision-maker. In theory, then, the fishery could be left entirely to the market without fear of biological depletion, excessive inputs in general, or incorrect combinations of inputs.

Unfortunately the phrase "in theory" is terribly confining. Most of these analyses, explicitly or implicitly, are carried out in long-term equilibrium terms, or assume that a dynamic analysis involves modifications only of degree rather than kind. The latter statement may be true in theory, but it is likely to be of small comfort to the fishery manager on the firing line.

Consider the following plausible scenerio. The scientists of the Fishery Management Council of Region X, gathered in solemn conclave, have decided that a reduction of fishing effort on a given herring stock is essential. They are asking for 50%, hoping for 35%, but being practical men of science will settle for 25% after the political process is completed. The fishery manager, having received this technical advice, then proceeds to make two simultaneous announcements. One is that herring stocks have been reduced (for whatever natural or man-induced reasons) to a point that requires a 25% reduction in catch. This will bring sadness to the fleet, since the income loss from a 25% reduction in catch of herring is unlikely to be offset by switching to any other fishery (most of which are equally hard-pressed), and alternative employment for either vessels or men is very restricted. Perhaps they will be comforted, however, by the manager's second announcement, which calls for a sharp increase in landings taxes — enough to bring about the desired decrease in effort either by redeployment or idleness on the part of the vessels affected.

How sharp is "sharp enough"? No general answer can be offered, of course, but in our not-so-hypothetical example factor mobility is not great in the fisheries involved, and it would take a very deep cut indeed to drive out enough effort to achieve the management objective. The cut would have to be even deeper than in conventional industries, since the share agreement, by design, buffers the impact of any reduction in vessel earnings on those who supply capital and entrepreneurship — perhaps the most mobile of the inputs in fishing. Acceptance of the medicine might be even more difficult if the target catch (and tax burden) must fluctuate widely from year to year.

None of this should be interpreted to mean that whatever other measures may be devised to reduce excess inputs would not benefit from an intelligently formulated tax program that would shape incentives in the desired direction. As has been thoroughly developed in the literature, the main requirement is that taxes be as factor-neutral as possible. A tax on landings is probably the best proxy that can be devised for a tax on effort, which is really the target. An ex-vessel landing tax is simple, straightforward in application and collection, relates the fisherman's use of the resource to his tax bill in an understandable fashion, and provides the widest possible latitude for individual adjustment to the cluster of management measures to which the vessel owner is subject. In addition, there may be merit in recent suggestions (e.g. McConnell and Norton 1978) that differential landings taxes in a mixed species fishery could improve economic output significantly by making use of self-interest of the fisherman and his limited ability to alter the species mix in his catch.

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[2] It has been suggested that the term "royalty" describes more accurately the charges to be levied and may raise fewer hackles. I agree but prefer to use terminology already used in the literature.

What I am most anxious to drive home is that taxes cannot be viewed as a short-term adjustment mechanism. Rather, a tax structure that pushes fishermen in the right direction with respect to total effort, the composition of effort, and deployment of gear in multiple species fisheries should be regarded as an essentially stable framework element in the overall management program. A number of other measures, fast-response in nature, must be at hand to deal with the inevitable perversity of nature and the unpleasant surprises that must be expected as long as management decisions must be based on data of uncertain quality, usually 1–2 yr out of date.

Limited Entry: Direct Control of Inputs

The second alternative (complementary rather than competitive) is to reduce total inputs directly, by restricting fishing to the holder of a legal right of access — a license, permit, or other legal evidence that a particular vessel and crew may use the resource. Again, the need for brevity suggests that we eliminate repetition of the controversy over licensing of vessels vs. licensing of fishermen. The purpose of the control is to reduce the number of fishing units that can participate. If fishermen are the constrained input some control inevitably must be exercised over vessel capacity if serious factor distortion is to be avoided. If vessel numbers alone are controlled, the same problem of restricting the application of additional labor and ancillary gear will arise, as indicated below, but at a lower level. Since the vessel is the core of the input system that makes up a fishing enterprise, logic suggests that it is the proper starting point for any restricted licensing system.

Even less purpose is served by debate over transferability. Efficiency in use, continuity of operation, and ease of administration are eloquent arguments for relatively free and costless transferability of limited fishing rights. The price they will come to carry is both an economic barometer and an allocative device that no amount of government administrative effort could match.

What, if anything, would be accomplished by a simple closure of entry, with all vessels that demonstrated a "reasonable level of activity" in the base period assured of a permit? Very little, in and of itself — but a great deal indeed if followed by a vigorous program to contain up-grading of inefficient boats, reduction in the total number of units, and other measures to induce the use of efficient vessel sizes and gear. At this point I simply wish to emphasize the critical need to freeze at least some key dimensions of an overcapitalized fleet to a past base period. Otherwise, the time-consuming process of developing a good multifaceted rationalization program (and guiding it through an indifferent or hostile legislature, usually in the face of well-organized opposition) leaves the speculative gate wide open.

Whether or not to reduce some excess capacity in the initial establishment of a base period and cut-off date is an operational question. In theory it would seem desirable to weed out, as far as possible, "dead" licenses and those taken out purely for speculation (since advance talk of a moratorium is bound to develop well in advance of action). Alaska attempted to combine a base period freeze with an elaborate point system to identify a smaller number of "worthy recipients." Whether or not the gain was worth the uproar and administrative effort is unclear, though Adasiak (1979) suggests that the intensity of the clamor was out of all proportion to the actual number of true hardship cases.

A less sophisticated but much easier way of accomplishing an initial reduction would be to establish minimum landings for qualification as "actively engaged" in the base period. If one were tough enough, a great deal of potential capacity could be eliminated at one stroke. Unfortunately, the cutting edge of such a measure is not as sharp as it appears at first glance. It would doubtless amputate a good deal of deadwood that could become effective capacity in skilled hands at a later date. But it would also eliminate an uncomfortably large number of efficient part-timers, and there might also be difficulties with highly productive fishermen operating on a well-reasoned schedule of limited participation in a number of fisheries in sequence. This could be resolved, however, by allowing credits for participation in what are recognized as complementary fisheries. On balance, there is much to recommend a fairly tough minimum landings requirement as an integral part of an initial freeze on new entry, particularly if backed up by a hearing board mechanism to deal with legitimate special cases.

Let us assume, then, that the moratorium is followed by a period of continued increases in demand and rising real prices. Whether or not any reduction in numbers of vessels has been undertaken, returns to vessel owners and share fishermen remaining in the fishery will eventually rise above opportunity levels. How far and how fast the rent component of income increases depends on the rate of increase in fish prices relative to fishing costs and the effectiveness of any efforts to reduce the number of licenses (via buy-back, minimum landing requirements, or techniques such as the British Columbia limited term nonreplaceable Class B license).

For the purpose of this enquiry assume that the rent component of gross fleet proceeds has assumed really juicy proportions. With an active market for licenses, and reasonably informed judgment among potential buyers and sellers as to income prospects, the capitalized value of the license should yield a price at which the purchaser could earn a competitive rate of return on investment only by fishing as efficiently as possible with optimal vessel and gear combinations. The only assumption required to make this completely general would be that each individual license holder, actual or potential, views his long-run marginal cost function as upward sloping.

But this would hold true only if the share of each restricted licensee in the fishery resource were somehow specified. If not, each vessel owner would probably perceive a range within which his share of the total catch could be increased by increasing the catching capacity of his unit, with the value of his expected increase in catch exceeding the increment in costs. If everyone plays the same game, of course, such expectations must turn out to be incorrect. Individual efforts to increase catches are mutually offsetting, and the only result is a general increase in average unit costs. Since the license is regarded as a sunk cost, there is no reason for the situation to be self-correcting. The lower rent will be accepted, since no single vessel owner could improve his position by reverting to a more efficient vessel/gear combination without losing catch volume that would more than offset the saving.

This has been worked over in detail by Pearse (1972), Fraser (1979), and others, and the theoretical aspects need not be elaborated further. It is important, however, to look at empirical evidence to determine how serious such induced imbalance in fishing inputs might be. Fraser, for example, suggests that the end result in the British Columbia salmon case may be as bad or worse than under open access.

The argument is persuasive, but the very pessimistic tone of its final conclusion is negated to some extent by the continued existence of very high prices for licenses in the British Columbia salmon fishery. (The same phenomenon of unexpectedly high license prices also shows up in the Alaska salmon fishery and even in Washington, which has done no more than institute a moratorium.) This can be explained in two ways: either there continues to be a net saving in real factor inputs compared to that which would prevail in open access; or fishermen have continued to entertain, for 10 yr, erroneous expectations. The latter seems a little hard to swallow. While it is true that the high returns earned by British Columbian salmon vessels and the correspondingly high license prices are a result of the extraordinary rise in salmon prices rather than the modest reduction in the number of licensed vessels, the price stimulus would certainly have induced further investment in new boats except for entry limitation. Indeed, the ultimate absurdity of the open access situation is the proliferation of additional fishing units solely as a result of increased prices in the face of an operative biological constraint on further catches.

Evidence that total investment in the British Columbian salmon fishery has increased, despite a decline in numbers of boats, is persuasive, though, as pointed out by Pearse and Wilen (1979), measurement of the change in total factor costs as a result of the limited entry program is extremely difficult. Unquestionably, windfall gains have accrued to the lucky holders of licenses blessed with legitimacy under the new program. But a substantial number of the licensees will have paid a lump sum which will permit a normal competitive rate of return on investment (and a normal rent for superior entrepreneural ability). It seems likely that fishermen are sophisticated enough, in addition, to recognize that a license initially acquired free of charge has an opportunity cost that must be included in the investment base on which the anticipated rate of return is weighed. The combination of these two factors will surely funnel licenses into the hands of better qualified, more professional entrepreneurs whose major occupation is fishing. Whether this is good, bad, or indifferent involves social and philosophical questions that are not at issue here. From an efficiency standpoint, it does imply that some of the increases in the prices of licenses reflect the shifting of licenses to better qualified personnel — surely a desirable outcome.

While it seems clear that there remains an incentive for operators to expand capital investment against a tonnage or length constraint, would this proceed to a degree that will dissipate all or most of the potential economic gain from the entry limitation program? Obviously this is an empirical question, not readily answered with available data. Perhaps the most important reason for my skepticism rises from the simple mechanics of the fishing operation. The vessel is, after all, only a platform that carries harvesting equipment. There are obvious limitations on the extent to which additional capital investment, whether in propulsion, navigation and depth finding gear, or any other variable can increase catching power if key proxies for increased fishing power such as tonnage and length are constrained. Hence any expansion in catching power from a given hull size will certainly be achieved at rising marginal cost. How rapidly costs rise is an empirical question that will vary, fishery to fishery, but they certainly will increase faster than if additional capacity could be provided by more vessels. A tax on landings, desirable on other grounds as well, would reinforce the effect of rising marginal costs from "capital-stuffing" a fixed-size vessel. Both sides are clearly making assertions; what is needed is careful quantitative measurement of the cost of inefficient factor combinations induced by the scheme.

Though it is impossible to quantify the proposition, there seems to be some merit in Newton's argument (1979) that investment in safer, more comfortable, and better equipped vessels is, at least in part, a movement in the direction of more desirable factor combinations, made possible because rising real prices for salmon and limited entry increased fishermen's incomes and, in the process, provided improved access to the capital market. (Adasiak and others indicate that bank financing of boats and gear has also become easier in Alaska and Washington.) To a limited extent, therefore, the observed trends in British Columbia may simply represent a reversion to a fleet composition that might have existed in the absence of such arbitrary restrictions, and, equally acceptable, rational choices by fishermen now enjoying better earnings and borrowing power to improve their own comfort and safety.

It should also be emphasized that any tendency toward excessive capital investment against a numbers–tonnage–length limitation is not necessarily related to the failure to siphon off all or most of the economic rent created by the program. A license fee of appropriate size would do that job, but would have no effect on the marginal cost-increased catch comparison that drives the individual vessel owner to overinvest. A tax on landings would help — not because it reduces retained rent, but because it adds to the incremental cost of additional catches. Efficient regulation does not require full adherence to Henry George!

Distribution Effects

A great deal of concern has been expressed over the possibility of undesirable distribution of benefits and costs of limited entry (and, by inference, any other intervention to rationalize a fishery). A professional version of this argument is presented by Bromley and Bishop (1977). In large part their argument is a polished restatement of the familiar proposition that optimal factor allocation will be different for each distribution of income, on the reasonable assumption that neither preference patterns nor the marginal utility of present versus future consumption will be identical at opposite ends of the income distribution. It also rests on the equally acceptable proposition that many fisheries are not suitable candidates for limited entry programs because the cost of data acquisition and the management framework necessary to utilize it efficiently would exceed any benefits that might accrue.

These arguments can be found in textbooks running far back indeed. Leaving aside for the moment the crucial analytical issue — how one determines that one income distribution is better than, or equal to, or worse than another — two practical problems dilute the impact of their criticism of the limited entry concept. First, once income distribution is introduced as one element of a complex objective function, other methods of achieving a desired distribution effect must be evaluated. Second, it seems unlikely that the differences in income distribution achieved by partial changes in such a small fraction of the total labor force would be of real significance, barring the "once for all" windfall gain that will accrue to the initial owners of licenses when a limited entry program is initiated. If the windfall to the original holders causes too much of a lump in the throat, it can be readily reduced by a tax on landings (and a consequent reduction in present value of the license).

Most programs aimed at reducing redundant inputs in the fishery affect income distribution in rather different ways than those with which economists have usually been concerned. The most important effect is to change incomes and employment opportunities by user group (i.e. gear types, fishermen in different areas, or commercial versus recreational users) rather than by income levels within the fishery as a whole. Most rationalization programs, carried on in a sensible way and at a sensible pace, need not create unacceptable income differentials within user groups or among fishermen on the one hand and other competing users of capital and labor within the regional economy. Although a landings tax would be preferable, almost any type of license, fee, or tax on favored participants would suffice to minimize this type of inequality. The more serious problems are not matters of egalitarian concern but rather the political pressures associated with changes in the position of competing fishermen groups, each with a vested interest in maintaining some aspects of the status quo.

Good examples abound. Reduction in the Pacific coast salmon troll catches would result in significant increases in both tonnage and gross value of total landings, since the trollers take large numbers of immature fish which would provide growth in excess of natural mortality if harvested later. But a reduction in the number of trollers would produce very small increases in catches to those remaining; the bulk of the benefits would accrue to inside net fisheries and to anglers. Similarly, reductions in catches of small cod in the North Atlantic would produce larger aggregate returns but at a cost of net losses to some nations and very significant gains to others.

A more important issue is raised by the choice of a base for comparison of distribution impacts. It was pointed out in the opening section of this paper that many open access fisheries characterized by market prices that are high relative to harvesting costs are likely to overrun long-term equilibrium positions where all inputs earn opportunity incomes. It is not particularly useful to assess the effect of any fishery rationalization scheme on the basis of relative income distribution effects within the fishery alone. The more relevant scale would be the regional economy, and in this setting reduction of excess inputs would seem virtually certain to reduce one pocket of persistently low incomes.

I cannot generate much concern over the allegation that limited entry schemes discriminate against potential new entrants. Their only "loss" would appear to be the opportunity to share the capital gains accruing to those grandfathered into the system. Thereafter, any current or potential operator of a fishing unit (assuming that the former accounts properly for the opportunity cost of his license and capital) faces precisely the same cost and revenue functions, and new entry is possible on the same basis as it would be in most other natural resource industries: purchase or lease of a right to harvest. It is surprising to find the fisheries singled out for special castigation because of the burdens imposed on potential new entrants. Why not equal concern over the plight of the young man who wishes to enter retailing, only to find that the cost of purchasing or leasing good retail sites (with a very high rental component) has risen astronomically in recent years? A quick glance at a semilog plot of farmland prices yields the same concern with respect to potential new farmers.

If the rationalization program includes, as every economist would hope, provisions for transfer of licenses with minimum transaction costs, entry is no more prohibited in the controlled fishery than in any other small business area. While this assumes reasonably free access to the capital market, the prices of licenses and the necessary physical equipment, although higher than fishermen have been used to in the past, are still very low relative to the requirements for entry into virtually any other field of selfemployed activity; and they reflect income prospects that have made conventional financing of boats and gear much easier. To the extent that the very young, untrained, and handicapped find entry more difficult because of the higher capital investment required, one can only reply that it is unwise to be poor, ignorant, or unwell — the same restrictions on entry that apply everywhere. A properly designed limited entry program does no more than prevent new entrants from inflicting additional costs on other members of society — fellow fishermen and the general taxpayer.

The Part-Timer Problem

One of the more perplexing aspects of both efficiency and distribution effects of a rationalization program is the treatment of part-time participants. Obviously, there are many fisheries in which part-time participation is dictated by the availability of fish, weather conditions on the grounds, or concentrations of fish sufficiently dense to permit them to be harvested economically. Most analyses of entry limitation, my own included, have tended to assume, uncritically, that economic efficiency would be improved if the fishery were to shift more and more to professional, full-time fishermen. While the basic argument still seems sound, in isolated communities a working schedule that combines the seasonal harvesting of certain species of fish with complementary seasonal activities in agriculture or forestry would be more efficient. The situation is muddied by the likelihood that fishing methods employed by a professional fishermen group, harvesting one species seasonally and then moving to others, would differ from those employed by a true part-timer shifting from a seasonal fishery back into agriculture, teaching, or some other low paid occupation. We can only fall back on the old standby — each case would require specific analysis of relative economic efficiencies under different configurations of the labor force.

Another dimension of the part-timer problem involves in-season mobility among different fisheries. Efficiency calculations and analysis of distribution effects based on the assumption of optimal factor combinations for units completely specific to one fishery neglect the real possibility that combination vessels, with or without additional fishing equipment, might earn larger net returns by shifting among different fisheries, not only between seasons but within seasons. Such flexible multifishery operation would influence not only the number of units that would be "optimal" for any one fishery, but almost certainly would alter the size, design, and equipment carried by the individual fishing vessel.

While I know of no empirical evidence to draw on, it is quite conceivable that license prices under limited entry would impede the development of efficient multiple fishery operations simply because the vessel license is indivisible. On the other hand, if license prices were reduced by an ex-vessel landing tax, the cost of part-time participation would be less of a deterrent.

Individual Fish Quotas

The final alternative considered — a rather old idea that has recently taken on new life (e.g. Christy and Scott 1965; Christy 1973) — would create rights to specific quantities of fish (individual quotas) rather than rights to participate in the fishery evidenced by a vessel or personal license. The notion is actually more flexible than this, since it could readily be modified to include percentage shares in a variable overall quota, or multiple species quotas with variable "exchange ratios" for fish taken by nonselective gear. Indeed the number of possible variants is one of its most attractive features.

The advantages of this method of management make it worthy of careful consideration. Since it works back from a predetermined total catch to the amount available to the individual operator, it offers much tighter control over each season's catch than either tax or licensing controls on inputs (both of which would have to be backed by area and/or time closures to achieve effective short-term control over the total harvest). Inseason and annual adjustments would be somewhat easier to institute. Individual quotas would allow a much greater degree of entrepreneural freedom to the individual fisherman. If the system is tightly enforced, there is no reason why his choice of vessel, gear, area deployment, or fishing time should be closely regulated. This is particularly important if multifishery operation is attractive, since it enables the fisherman to exercise a wide range of options as to time, area, and intensity of participation in each. The investment in rights would be limited to that quantity actually required for each fishery. The system should encourage technological development and innovation; better gear and techniques would simply raise the price of existing quotas without subjecting the resource to a surge of new fishing mortality.

There is no apparent incentive under an individual quota system to overinvest in the vessel and gear — or, to be more precise, to select anything but the least cost combination and deployment of inputs. Income effects would be much the same as under a license limitation scheme.

There are, of course, some thorns on the rose, and though they are more administrative than economic in the narrow sense, they are no less real in implementing a rationalization program. The first is enforcement. In theory a fish purchase ticket of the type now widely used for both business and statistical convenience should provide an accurate check on compliance with an individual quota. But unless an inspector stands at the shoulder of each person preparing the ticket, odd things can happen (e.g. unless most fish are under the quota systems, simply reporting a controlled species as an uncontrolled item opens the door to widespread evasion). Moreover, for very valuable species — salmon, halibut, etc. — new distribution channels can open up with surprising speed, and they would be very hard indeed to pinpoint. A similar, though less serious factor to be considered is that the quotas will always be taken — if I fall short I can readily buy from someone else who has filled up but is still available to fish (transfering at sea if necessary).

The problems of enforcement are not unique to the fisherman quota option, of course. They would be at least as serious in a program that relied on taxes alone, but would probably be less troublesome under limited licensing.

The individual quota, freely transferable, will act as a rationalizing device on a brute force basis. In effect, the price mechanism is substituted for taxes as a way of forcing out inefficient users of inputs. Competition for quotas will force prices to levels that may impede the achievement of other social objectives, e.g. protection of small-scale operators and of isolated fishing communities whose efficiency is lower. Even if prices are allowed to ration out the least efficient users, it would probably be necessary to undertake a quota repurchase system, comparable to the buy-back efforts under license limitations; and, as in those cases, increasing taxation of remaining operators would be necessary if the buy-back scheme is to remain solvent.

Finally, introduction of a quota system on a substantial scale would require an educational program that would be both costly and time-consuming. Fishermen are not prone to jump at new ideas, particularly if the impact on the individual is both complex and uncertain, and quotas would represent a drastic departure in regulatory techniques. Where the fishery is simple in structure (Pacific halibut or king crab, for example), it might be possible to move fairly quickly, but the reaction of fishermen and fishery managers in the complex salmon and multispecies bottom fisheries would probably be negative.

On balance, there may be less difference in implementation of license limitation and quota systems than meets the eye. Both are potentially capable of generating net economic benefits by shedding redundant capacity at a controlled rate that could demonstrate success without imposing more than minimal hardship on existing participants. Both would favor the more skillful and energetic fishermen. Both would have to be tailored to meet the special needs of the isolated, economically immobile fishing community. Both must be backed up by a tax system that pushes in the right direction with respect to factor combination and overall input usage, shifts the cost of management from the general taxpayer to the producers and users of fish, and prevents unacceptably large windfall gains. Limited licensing is more prone to distortion of factor combinations, but could be introduced more rapidly and with less confusion and hostility than individual quotas. Both create the danger of redeployment of labor and capital to other fisheries unless special measures are taken to prevent it. Both would benefit from a moratorium that has some braking effect while a detailed program is being developed, sold to politicians and the industry, and put into operation (none of which can be accomplished overnight).

Rationalization and Market Structure

The political obstacles to rationalization of marine fisheries are formidable indeed. One of the more formidable — and least defensible — is the argument that any kind of entry limitation constitutes monopolization — or at least the creation of a "privileged class."

The danger of monopolistic practices seems greatly exaggerated. Canadian and American fish are sold largely in national and international markets. Cross elasticities of demand for any given fishery are therefore high, and for most products the availability of imports establishes a firm ceiling on prices at the wholesale and retail level. Under any scheme in which access to the fishery requires purchase of a transferable license or fish quota, there is no more restriction on entry to the fishery than there would be to agriculture in an area where arable land is physically limited. It is true that a limited entry or individual quota scheme would create a body of fishermen with strong common interests in improving prices received for their product, and formation of a single bargaining unit would be correspondingly easier. The possibility of a limited cartel exists. But, as with any other cartel, the ability to restrict output below levels that would otherwise prevail requires that the cartel be able to allocate shares among the band of brothers in an acceptable manner and to enforce those allocations. Otherwise, the familiar tendency in all cartels for one or more members to expand shares of the restricted output — to benefit from the "umbrella" without assuming its responsibilities — becomes overwhelming.

In the case of a fishery, the difficulties of establishing and policing allocations of a cartel-determined output lower than would otherwise have been harvested would appear to be nearly impossible. The number of fishermen involved, the variability of resource availability in the short-run, the complexities imposed by participation of individual units in more than one fishery, and a host of other circumstances attendant upon commercial fishing would make the maintenance of effective monopolistic restriction a cartel manager's nightmare. Reconciliation of the interests of competing gear types, part-time versus full-time participants, and other group objectives within the cartelized fishery would make the balancing act even more difficult.

With respect to market structure, a stronger case could be made that the creation of a group of fishermen holding private property rights would tend to redress the market power now heavily titlted in the direction of the waterfront buyer. Waterfront markets for marine fish tend to be oligoposonistic in structure, since the processing firms, though not large in absolute terms, are usually large in terms of the restricted geographic areas over which fish can economically be transported to first receivers. This imbalance of economic power has been partially offset by unionization, by the formation of fishermen's cooperatives, or by government action to eliminate control over potential new entrants at the buyer level. The addition of a limited entry program would create a new negotiating environment with respect to first receivers, but it is difficult to envisage any real threat of monopoly by fishermen or bilateral monopoly leading to restrictive joint maximization policies by fishermen and processor groups. To do so would require a degree of policing and overt enforcement that could be readily detected and attacked under existing antimonopoly legislation.

Some Invalid Objections to Rationalization

I now turn briefly to some criticisms of limited entry systems of the licensing type that are also applicable to any rationalization scheme.

One of the astonishing aspects of recent discussions of controlled access is the widespread agreement that limiting inputs is not significant as a "conservation" measure, that is, as a means of holding physical catch to some predetermined level. While other methods of restricting fishing mortality can achieve any given impact on stocks, it is equally true that reduction in effort, if pursued far enough, can achieve the same result. Moreover, in some major fisheries (Pacific salmon and halibut, for example) the effect of open access has clearly been to reduce total yield in weight over time as a result of severely unbalanced harvesting of several substocks within the total populations.

Perhaps the best way to deal with the whole matter is to dismiss the relevance of "competition" between limited entry and more direct methods of limiting fishing mortality as means of achieving a desired level, composition, and area distribution of fishing mortality. They are complementary rather than competitive techniques in real world fishery management even if, hopefully, more reliance will be placed on rationalization in the future.

Another of the myths that seems to pervade the recent literature on limited entry programs is the alleged failure to reduce prices to the consumer. To the extent that limited entry, coupled with other techniques, permits rebuilding a previously depleted stock, it is possible that increased output could exert some downward pressure on prices, but only if it more than offsets the secular increases in demand which have been evident for many decades on a worldwide basis. Rationalization of fishing is not intended as a means of increasing output (though that may be a desirable by-product) but rather of assuring that any given output will be taken at lower cost — certainly with fewer fishing units, and less certainly, with more desirable factor combinations within harvesting units. To reiterate a point that has been made repeatedly in previous discussions by economists, the principal gain to the general public from a more rational fish harvesting sector would come from increased output and lower prices of other goods.

Another of the more dubious arguments against rationalization of fishing is based on the impetus to exploitation of latent or underutilized resources provided by excessive capitalization in the more valuable fisheries. It is doubtless true that exploration and development of new tuna grounds in the western Pacific was carried out more rapidly than would have been the case had the eastern Pacific not undergone a tremendous influx of vessels following the successful introduction of the high seas purse seine. Similarly, it may be that substitution of American for foreign exploitation of pollock, hake, and other low valued groundfish of the north Pacific will be accelerated by growing excess capacity in the king crab fishery. But surely this would be an optimal use of inputs only by sheer chance. The economic rent from efficiently exploited yellow-fin tuna and king crab stocks could have provided revenue for subsidization of directed exploration and development at far lower total cost. In a narrow technical sense, it might also be pointed out that the vessels most likely to be squeezed out of an overcapitalized fishery are the older, less efficient units — hardly the ones that would be picked for risky and innovative exploratory fishing.

A considerable amount of nonsense has been written (e.g. Cicin-Sain 1979) about the impact of limited entry programs on unemployment — in the fishery, and in associated industries in coastal ports. It is hard to view this as a really serious problem in general terms. For example, the total number of fishermen engaged in the salmon fisheries of Washington is substantially lower than the quarter-to-quarter fluctuations in employment by the Boeing Company. None of the existing limited entry programs and none of those proposed, to the best of my knowledge, have ever implied that large numbers of fishermen would be forced to seek other occupations involuntarily. Most have started with a moratorium applying to existing license holders, coupled in some instances with procedures for weeding out "paper" licenses acquired speculatively in anticipation of limited entry. Any subsequent reduction in gear has been based on a buy-back program or some other method of attrition resting on voluntary relinquishment of licenses. The problem, if there is one, is to redirect the flow of potential new entrants from the fishery to other occupations. Since this involves redirection of younger men with a wide range of education and employment opportunities, it is difficult to see how sensible implementation of a gear reduction program would exert any significant effect on regional unemployment.

An important exception would be in isolated fishing communities where other employment opportunities are severely limited. It is quite possible that spreading employment in the fishery would still represent the least-cost method of achieving some desired minimum economic and social standards. But this is a matter to be determined by study, not simply assumed. Otherwise, there is a very real danger that the basic problems of inadequate regional employment opportunities and immobility of younger entrants to the labor force will be neglected, since the fishery constitutes an easy dumping ground for excess labor inputs.

The argument that secondary activities associated with the fishing industry will be adversely affected by a limited entry program is even less convincing. It is true that boat building would be adversely affected, particularly if prospects for continued increases in fish prices are realized, but is precisely what a limited entry program is intended to achieve — a reduction in the totally useless accumulation of excess capital in a fully utilized fishery.

Rationalization has also been opposed on the ground that it constitutes an obstacle to the realization of some optimal combination of income and nonmonetary satisfactions derived from the occupation itself (Orbach 1979). But surely the same combination of benefits from employment accrues to most occupations — teaching, farming, professional and managerial work, and professional sports come to mind as obvious examples. It is also worth emphasizing that open access, particularly in areas where fishermen have enjoyed rapid increases in product prices, has frequently generated a flood of entry which has reduced opportunities for the dedicated fishermen about whom the emotion centers. For example, large increases in salmon trolling and gillnetting by people with only a minor interest in or commitment to commercial fishing has made it extremely difficult for more professional fishermen, presumably those to whom the "way of life" argument applies most cogently, to enjoy that way of life and still eat regularly. It should be emphasized that the situation in isolated communities may involve a very different assessment of the way of life argument, particularly where there are strong cultural ties to the industry (as in the case of many of the Indian and Eskimo fisheries of the Pacific northwest).

Conclusion

Perhaps our legitimate concern with the problems of each major policy option for rationalization has blinded us to the very real gains that can be realized if our sights are not set too high. Any system to reduce excess capacity in a marine fishery will be suboptimal in a formal economic sense. Other nonefficiency objectives must be accommodated; fisheries will always be subject to wide, unpredictable fluctuations in natural abundance; and any real progress calls for institutional changes that will find heavy going in the traditionally conservative fishery community (industrial and governmental). But the weaker welfare test for efficiency is clearly met by any reasonably framed rationalization program that stabilizes total effort in the face of rising prices and/or reduces it with rising or constant prices. Those leaving the fishery could conceivably be fully compensated for any loss of real income (and, if it could be defined, a cash payment to compensate for noneconomic satisfactions derived from participation) while leaving sufficient gross income to provide opportunity returns or better to the owners of all inputs remaining in the fishery. To the extent that a rationalization program carried far enough to warrant such an efficiency test might also increase the physical quantity of fish that can be taken over time, reduce the impact of errors in short-term management decisions, and eliminate the need for efficiency-killing regulations, the case is even stronger. If the rationalization program is phased in time to permit reduction of unnecessary inputs on a voluntary basis, the program would come very close to meeting the stronger test that there be no losers, though certainly with unequal distribution of net benefits.

Much of the discussion of limited entry programs seems to take it for granted that rationalization will add substantially to the cost of management. This is unquestionably true during the early stages of the program, since a change of objectives and techniques of public intervention can hardly be achieved without building new data bases, creating new institutions, and, if the program's advocates have any common sense at all, a major educational effort. But what of the future? Hopefully, programs can be designed that will reduce unnecessary inputs steadily over time until a reasonable level of economic efficiency is realized. Shifting a substantial part of management to the market mechanism and eliminating some of the more ludicrous (and therefore difficult to enforce) gear and vessel restrictions might be expected to lighten the administrative burden. The costs of doing nothing or of continuing to stifle the efficiency of a steadily rising amount of fishing capacity to save the resource are increasing very rapidly. The essential question is not whether rationalization programs increase management costs but whether they produce net benefits. On balance it would appear that they can do so; whether or not they succeed will depend on the determination with which industry, government, and concerned academics tackle the jobs of design and implementation.

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Symposium on Policies for Economic Rationalization of Commercial Fisheries

PART II

Evaluation of Rationalization Programs

Limited Entry: Experience of the British Columbia Salmon Fishery[1]

G. ALEX FRASER

Department of Fisheries and Oceans, Salmon Enhancement Program, Vancouver, B.C. V6E 2P1

FRASER, G. A. 1979. Limited entry: experience of the British Columbia salmon fishery. J. Fish. Res. Board Can. 36: 754–763.

In 1969 a program of limited entry was introduced in the B.C. salmon fishery; this indicates the near desperation of Fisheries managers at the apparent bankruptcy of more traditional management measures. Also, this introduction represents a significant break in traditional management orientation. The goals of management were broadened to encompass not only resource conservation, but also socioeconomic rationalization. Unfortunately, the program was ill-designed to achieve either objective. In spite of license limitation it appears that fishing costs and fishing capacity are still growing at a rapid rate. Although vessel numbers are declining, much of the potential benefits are being offset by increasing capacity and capital intensity in the individual vessels that now make up the limited fleet. While some benefits may remain from the program due to the rapid increase in the value of the salmon resource over recent years, the distribution of these benefits is somewhat anomalous. The public purse has gained little because license revenues represent a small proportion of the total management costs of the fishery. At the same time, it cannot be interpreted that fishermen will be the long run beneficiaries of the program. The only clear winners are the original group of license holders. Various adjustments in the structure of the licensing program have been considered to address these problems. While the most practical and effective of these is a system of landings royalties or taxes on output, it remains the least politically attractive. If the British Columbia licensing program is to become an effective vehicle for decreasing fishing costs and fishing capacity, some difficult decisions are required.

Key words: overcapitalization, salmon management, fisheries economics, fisheries management, fisheries policy, fish licensing, license limitation, fish royalties, tax on fish landings

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On introduisit en 1969 un programme de limitation des entrées dans la pêcherie de saumons de la Colombie-Britannique. Cela reflétait le quasi-désespoir des gestionnaires face à l'apparente banqueroute des mesures de gestion traditionnelle. En outre, cette introduction représente un changement important dans l'orientation de la gestion traditionnelle. Les objectifs de la gestion furent élargis pour englober non seulement la conservation de la ressource mais aussi la rationalisation socio-économique. Malheureusement, le programme était mal conçu et ne pouvait réaliser ni l'un ni l'autre de ces objectifs. Il semble que, malgré la limitation des licences, les coûts et la capacité de pêche continuent de croître à un rythme accéléré. Bien que le nombre des bateaux diminuent, la plupart des bénéfices qui pourraient en résulter sont annulés par une capacité et des investissements accrus pour chacun des bateaux qui constituent maintenant une flottille réduite. Grâce à l'augmentation rapide de la valeur du saumon en ces dernières années, il reste encore quelque profit découlant du programme. Par contre, la répartition de ces bénéfices est quelque peu irrégulière. Le trésor public n'y a pas gagné beaucoup car les revenus provenant de la délivrance de licences représentent une faible proportion des coûts totaux de la gestion de la pêcherie. On ne peut pas dire non plus que les pêcheurs seront les bénéficiaires à long terme du programme. Les seuls gagnants sont le groupe originel de détenteurs de licences. En vue de résoudre ces problèmes, nous considérons divers ajustements à la structure du programme de délivrance de licences. L'ajustement le plus pratique et le plus efficace est un système de royautés sur les débarquements ou de taxes sur les sorties. Il est par contre politiquement le moins attrayant. Il y aura de difficiles décisions à prendre si l'on veut que le programme de délivrance de licences en Colombie-Britannique soit un instrument efficace de réduction des coûts et de la capacité de pêche.

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THE general problems with open access fisheries have been adequately dealt with elsewhere (Scott 1979; Crutchfield 1979) and need not be belabored here. However, the scale of these problems in the British Columbia salmon fishery is worthy of some emphasis. Due to the relative ease of exploitation and relative value of salmon, the need for government action was obvious in this fishery at a very early date. In the 1880s, only a few short years after the establishment of the first commercial cannery in the province, overfishing began receiving serious attention.

In general, the Department of Fisheries reacted along traditional lines. Over the years closed seasons, closed areas, and restrictions on more efficient gear were all used in an attempt to restrict the catch to a biological sustainable maximum. As in other instances where these traditional mechanisms were used, it was evident that only the symptoms and not the underlying cause of the malaise was addressed. The pattern of competition among fishermen for a share of the limited resource continued by simply adjusting to the particular form of the regulations.

Over time, as new vessels entered the fleet and all vessels became more effective in their exploitation of the resource base, increasingly stringent gear, area, and time regulations were necessary. Gradually the ability of these traditional measures to protect the resource base was seriously impaired. As fishing capacity grew in relation to biological availability, the consequence of even minor management error in openings and closures could be the total demise of a salmon stock. Also, economic waste in the salmon fishery was becoming increasingly evident. While openings became shorter and the availability of the resource declined, or at best remained constant, the number of vessels and fishermen employed in the industry continued to increase. As predicted by the economic theory of open access fisheries, the costs of exploitation rose in conjunction with the value of the resource base.

By the late 1950s these problems had reached crisis proportions, and some new forms of control were clearly imperative. As a result, in 1958 the Federal Government commissioned an intensive study of the salmon fishery by the economist Sol Sinclair. Building on the economic theory as developed in the 1950s by Gordon (1954), Scott (1955), and others, Sinclair identified the underlying cause of the problems as economic. In his final report, he recommended as a solution that entry be controlled to the salmon fishery through some form of license limitation (Sinclair 1960).

While the general concept of license limitation was acceptable to the vast majority of participants in the industry, and in fact had been recommended periodically by the major fishermen's union, a full decade of debate ensued regarding the particular form a program should take. Any management system aimed at eliminating the tendency to dissipate the potential net value of the resource will, if it is successful, generate benefits. Understandably, each group of participants (companies, fishermen, and vessel owners) will advocate positions that favor themselves in the distribution of those benefits (Sinclair 1978). This was eminently clear in the variety of opposing submissions that arose from Sinclair's work. At the same time, the 1960s was a decade of "minority" federal government, and a consequent reticence to implement politically sensitive programs without concensus from industry.

Finally, however, with the election of a majority government in June 1968, the stage was set. In the following few months a basic licensing plan was prepared, and the industry advised that it would be effective for the 1969 fishing season. The following section details the eventual structure of that program. Later sections evaluate performance through its first decade of existence and speculate on some proposed changes.

Structure of The Program

As already indicated, the program introduced had two basic objectives, (a) economic rationalization and (b) biological management. An important secondary objective related to the speed of the rationalization process. It was intended to minimize the dislocation of the capital and labor currently employed in the industry. The plan designed to accomplish these ends encompassed two general phases. The first was to freeze the fleet at a stable level, while the second was to effect a gradual reduction in that fleet from its already excessive level. A final phase was originally conceived to reduce the plethora of gear, area, and time regulations on the fishery. Many of these were having a direct and detrimental effect on operating costs, and thus relative returns to fishing vessels and fishermen. It was felt, with a smaller fleet, that the more obviously detrimental regulations could be removed or adjusted. However, this phase is as yet unimplemented, and given present conditions in the industry, it appears unlikely it will follow in the near future.

PHASE I

In the first phase, the fleet was frozen by creating a specific salmon license in lieu of the general license previously available. These new licenses were originally available only to those commercial fishermen recording salmon landings in the two base years 1967 and 1968. Eventually, however, this was relaxed to qualify vessels that had fished for any species during the base years. It was argued that these vessels traditionally participated in the salmon fishery during peak runs and their exclusion from licenses would detrimentally affect both their long run income and vessel values.

The license was made a vessel license rather than a personal license on the individual fishermen. The rationale for this lay mainly in the administrative and policing necessities of the program. Under a personal licensing system, as the licensed individual moved from vessel to vessel, it would prove difficult to determine which vessels were fishing legally and which were not. At the same time, because of the high mobility and large size of the fleet, it would be impractical to rely on self-policing of the fishermen themselves. Undoubtedly, vessel licensing posed some equity problems for those fishermen who operated rental vessels or acted as crewmen, but at least the vessel is a concrete clearly specified entity. In terms of field management it is relatively simple to determine its status and in terms of administration relatively easy to control its replacement.

A further step taken during Phase I was to subdivide the vessels qualifying for the salmon license into "A" and "B" categories on the basis of their performance history. In monetary terms, the production cutoff between the two categories was quite low at approximately $1250 or 20% of the average gross income in either of the 2 base years. The intention here was to identify (a) serious fishermen in the sense that a reasonable income was derived from the resource, and (b) part-time or recreational fishermen whose main source of income lay in other occupations.

A final aspect of Phase I worth noting is the controversial aspect of license transferability. The licenses, when allocated, were made freely transferable upon sale of the fishing vessel. Transferability has been the subject of an on-going debate both among fishermen themselves and within the Department of Fisheries. It is claimed that it has led speculative excess, windfall gains, and a number of other associated evils. Rather than examine these criticisms directly at this point, the originally perceived advantage of license transferability should be emphasized. If upon sale of a salmon vessel the salmon license could not be retained, clearly the sale value of the vessels would be seriously affected. A salmon vessel is of very specialized design and its consequent alternative use value is very low. The potential capital losses to retiring fishermen through nontransferrable licensing were considered unacceptable.

PHASE II

Under Phase I, the licensing program was designed to limit growth in fleet size, but did not address the problem of reducing that fleet from its already excessive level. This was the essential focus of Phase II. The main features were 1) a substantial increase in license fees, 2) the eventual phase-out of the "B" licensed fleet, and 3) the introduction of a "buy-back" program.

Effective for the 1970 salmon season, license fees were raised from their nominal $10.00, to $100.00 for category "A" vessels less than 15 net tons in capacity. Vessels larger than this were charged $200.00 fees in a rough attempt to make fees proportional to fishing capacity. Effective for the 1971 season these fees were doubled to $200.00 and $400.00, respectively. While "B" license fees were kept at a $10.00 level, a 10-yr phase-out period was announced. It was hoped that these provisions would encourage operators to voluntarily opt for "B" status and eventual retirement from the industry.

The decision to eventually eliminate the "B" fleet was both politically and economically motivated. In the short run, the catch for these vessels was minimal and their elimination would add little to the income of the remaining fishermen. However, part-time and casual fishermen had been a contentious issue for a number of years. The more serious fishermen naturally objected to the nuisance hazard of amateurs crowding the fishery and taking a share of the limited catch they felt rightly belonged to them. At the same time, with the now limited fleet size, there could be no guarantee that these vessels would remain casual participants in the fishery. The possibility that the current owners would sell in favor of more serious participants was a definite threat. The long run result might be an effective increase in effort from these vessels that would circumvent the program's intent. The phase-out decision was intended to combat both of these problems.

The last major feature of Phase II was the creation of a buy-back program. To speed up the rate of attrition, the proceeds of the higher license fees were channeled into a fund. Beginning in the 1971 season, this fund was used to enter the "A" licensed vessel market with the purpose of purchasing and retiring a portion of the fleet. While the suspension of this program was eventually necessitated in 1973, due to a record salmon harvest and the consequent spiralling value of "A" licenses, by the time of its suspension the program had succeeded in retiring 350 vessels or about 7% of the "A" licensed fleet.

Program Effectiveness

This then, was the basic structure of the program. Although certain qualifications were voiced soon after its implementation (Pearse 1972) on the whole, it appears largely successful with respect to its secondary objective. The dislocation of the capital and labor already employed in 1969 was effectively minimized. In the original licensing, any vessel that had even minor dependence on the fishery was granted a license. During the second phase reduction in fleet size, no vessel was involuntarily forced out of the industry. Even those in the "B" fleet which played a very minor role were given a 10-yr phase-out period. Those low producers in the "A" fleet who could not afford the increased license fees still had the alternative to down-grade their licenses and continue paying nominal fees. Finally, the "buy-back" program was operated on a purely voluntary basis. A fair market price was given for those vessels offered, and the options always remained open to either continue fishing or to sell elsewhere on the open market. On this basis, it must be concluded that those individuals who used the opportunity to leave the industry made reasonable decisions in light of their personal alternatives.

THE ABSOLUTE CASE

With respect to the more basic objectives, it appears on a superficial level that the program is also a reasonable success. In 1967 and 1968 approximately 6500 vessels engaged in the salmon fishery. On the basis of that participation 6932 vessels qualified for salmon licenses in 1969. This number has gradually declined until by 1977 only 5300 licensed salmon vessels or 77% of the base fleet remains. Of this number approximately 600 are "B" licensed vessels slated for removal in the near future.

Unfortunately, this trend is extremely deceptive; a more rigorous examination raises a good number of questions regarding program effectiveness. As noted by Pearse and Wilen (1979) the real objective of the licensing program was to reduce the amount of capital and labor employed in the fishery. Vessel numbers are actually no more than a proxy. For the decline in vessel numbers to represent proof of a decline in fishing costs or fishing capacity a necessary condition is that the vessels themselves represent a standard unit over the years. However, the available evidence simply does not support such a conclusion; on the contrary, it implies that the average fishing vessel has become both larger and more capital intensive.

If the decrease in active salmon vessels is examined closely, it is apparent that the decline has not affected all sectors of the fleet. There are three basic gear types used in the British Columbia salmon fishery: purse-seine, gillnet, and troll. Over the first few years of license limitation, the seine fleet remained relatively constant at approximately 400 vessels, but has since increased dramatically to its current level of 514 vessels. The purse seiner is the largest operation in the fishery using a crew of five or more, and vessels ranging in excess of 50 ft in length; in contrast, gillnetters and trollers tend to be one or two man operations in a 30–40 ft length category. As a consequence, this gives a dramatic indication of the pattern taken by fleet reduction. While there is a substantial decrease in overall fleet size, it is the smaller rather than the larger vessels that have been eliminated. The number of larger vessels in the fleet has actually increased over the years.

Other similar trends in the fishing fleet are readily apparent. Traditionally, a number of salmon vessels have used two or more salmon gears during the year, or fished for other species during the off-season. Since 1969, this "combination" sector of the fleet has also witnessed growth rather than decline. In particular, the overall increase in the number of seiners was entirely due to a substantial increase in the number of combination units. Clearly, a vessel that can use a number of gears rather than a single operation is more capital intensive. The various modifications required and the expense of the additional gear adds to both vessel value and operating costs.

Within all fleet sectors, various indicators of average vessel size and capacity show significant increase over time. In particular, the upward trend in vessel motive power is dramatic. Average engine horsepower increased by 47% for the gillnet fleet, 43% for the seine fleet, and 36% for the troll fleet between 1968 and 1977. Average vessel length increased by 6, 10, and 11%, respectively. Also, average net tonnage, a basic measure of vessel carrying capacity, increased by 24, 11, and 17%, respectively. In summary, the average vessel in the current fleet is larger, better equipped, and far more mobile than its counterpart in 1968.

These various factors have substantial implications for the underlying capital employed in the industry. The estimated market value of the fleet has increased from \$73.4 million in 1968 to a level of \$273 million in 1977. Although this trend is deceptive, due to capitalized license values,[2] previous work attempting to factor out this element indicated that the nominal capital employed in the industry had increased to \$161 million by 1975 (Fraser 1977). Even allowing for the rapid inflationary spiral in boat-building and repair costs, the real capital employed had increased by \$36 million, or 49%. Evidence since that time indicates that further increases may have occurred.

While there is some evidence that the absolute amount of labor employed in the industry is declining, it is difficult to conceive of this as a complete offset against the dramatic increase in capital costs. The estimated number of individuals employed in salmon fishing has declined from about 9600 in the prelimitation period to perhaps 8600 at the present time. At the same time, however, real wage rates in the Province have increased by approximately 28%. In other words, it is unlikely that the real labor costs incurred in salmon fishing have declined at all.

THE RELATIVE CASE

It is necessary to emphasize at this point that a completely static judgement of the program may be somewhat unfair. Apart from the usual cyclical fluctuations, the biological resource has remained relatively constant over the years; in contrast, market conditions have changed dramatically. Since 1969 the value of the resource has risen at an overall faster rate than ever before. The average landed value of the catch over the 3 yr before license limitation was \$36.2 million, while the average landed value over the 3 most recent years was \$80.5 million. In real terms the value of the resource has increased by about 35% (adjusting by the Consumer Price Index).

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[2] Since the license is attached to the vessel and can only be transferred with the vessel, the reported market values tend to include the value of the license. In this way market value overstates actual capital employed.

In the absence of license limitation, and in keeping with the economic theory of free entry, this increase in the value of the resource would have resulted in a dramatic increase in the costs of fishing. Undoubtedly, the fleet would have expanded rapidly in response. In this light, a relevant question is whether limited entry has effectively constrained this trend.

In this respect some preliminary work shows the growth in fleet capital value since 1969 as even more rapid than before license limitation (Fraser 1977). In effect, the responsiveness of capital employed to changes in the resource value may be more effectively dissipating the potential rent from the resource. However, this conclusion must be qualified; there were a number of relevant factors that were not considered in the analysis. In recent years new markets have opened up that have created high demand for previously unexploited or underexploited species. In this respect the roe herring fishery is extremely noteworthy representing, as it does, a season in minimal conflict with salmon. This resource jumped from a minimal $2.7 million landed value in 1972 to a substantial $32.5 million in 1977. Many of the vessels involved in the purse-seine component of this fishery are salmon seiners. A part, and perhaps a substantial part, of the growth in seine fleet capital may be a function of this resource. Thus, while the costs of salmon fishing appear to be rising, the net effect is unclear. While a proportion of the potential rent is being dissipated, whether it will be dissipated in its entirety is uncertain.

Since the 1973 salmon season, salmon licenses have been worth a good deal of money. According to estimates made on a control group of vessels, an average license sold for approximately $17 000 in 1974 and $10 000 in 1975 (Fraser 1977). Although no direct estimates of license values in 1976 and 1977 are available, indications are that they have appreciated somewhat over the interim. These license values theoretically represent a capitalized resource rent and this should not exist unless some wedge has been driven between fishing revenues and fishing costs. However, other factors may account for the phenomenon; license values may simply reflect unrealistic expectations on the part of fishermen themselves. The fact of license limitation itself may simply have encouraged a more optimistic view regarding future net income levels than will actually be borne out by events. Also, in the last 2 years a large-scale Salmonid Enhancement Program has been initiated and this too may be unrealistically raising expectations within the industry.

Even bearing this in mind, however, the continued existence of a positive and quite high license value is a strong indication of some relative success. If expectations were unrealistic, a downward trend in license values could be expected. In contrast, they have continued in existence for 5 years and retained a relatively high value even during a disastrous year in 1975 which saw landings plummet to less than 60% of the 10-yr average. On this basis, the program is at least a qualified success with respect to its primary objectives. Fishing costs and capacity have been constrained below their free entry levels to some degree.

Distributional Considerations

To this point, nothing has been said regarding distributional objectives of the program. However, if indeed the program has been a qualified success in preventing the full dissipation of the potential rent from this very rich resource, a relevant question is to whom that rent accrues and to whom it was intended to accrue. As indicated by Pearse and Wilen (1979), in public announcements regarding the program a key group of beneficiaries were to be the fishermen themselves. It was emphasized that any economic surplus generated would raise the level of fishermen's incomes. Another distributional objective of the program understandably did not receive as prominent public attention due to the potential sensitivity of the issue. However, it was explicit in many minds that the rationalization program would eventually enable government to appropriate a rent from the resource in compensation for the rapidly increasing costs of fisheries management (Campbell 1971).

With respect to this latter objective, the annual license fees collected can be viewed as an appropriated rental. Since 1972 this public share has approximated $1 million/yr. Since 1973, and the dramatic increase in the value of the resource, this amount has been generally declining as a proportion of the total resource value. Overall it is quite marginal, in 1977 amounting to less than 1% of total landed value. At the same time, current salmon management costs run at approximately $20 million/yr. It is clear that the current license fees cannot be considered significant in relation to management costs, or even the increased costs of management since 1969. It is clearly ludicrous to consider them an adequate return for the use of a valuable public resource.

The other desired beneficiaries were the fishermen themselves. Undoubtedly this was partly politically motivated as the price for, if not support, at least acceptance of any licensing plan. Partly, too, it was socially motivated; salmon fishermen appeared generally worse off than other participants in the economy. A survey of fishermen in 1970 revealed an average net operating income of $3269 from salmon fishing. Even including earnings from other sources, the average total income was only 70% of the average industrial wage in the Province (Fisheries Service 1971).

Given the structure of the program it is highly questionable whether even this distributional objective has been attained. Undoubtedly, a specific group of individuals have benefited, namely those operators who were originally licensed in 1969 or purchased their way in during the first few years of the program. However, those fishermen who have entered the fleet since 1973 have paid a high premium for that privilege. In many cases the price paid to enter the industry in the form of purchasing a license has vastly exceeded the price paid for the purchase of a vessel. License values are, in effect, and ignoring possible unrealistic expectations, the capitalized benefits of the program. In paying a license price, new entrants in recent years have effectively transferred those benefits to the seller of the license privilege. On net, it appears that these new entrants have gained little from the program. Indeed, in 1973, due to a large run and rapid price increases for salmon, some new entrants clearly paid excessive prices for licenses. These individuals may actually be worse off than in a situation of free entry.

In the long run, as the original license holders retire, all fishermen will become new entrants. There is no convincing reason to believe that future fishermen will be better off as a result of limited entry. The only clear beneficiaries will be the original license holders. This distribution of the net value of a public resource is not necessarily a social optimum, but in fact could be described as a social anomaly.

Proposed Changes

The various problems with the ongoing performance of the licensing program have been recognized for some time. To address them, numerous proposals have been put forward and discussed over the years. First, a variety of additions to the regulations have been suggested with the main intent to increase difficulty in raising the capacity and capital intensity of the individual vessels' in the fleet. A second suggestion concentrates on the social and distributional aspects of the current high license values. The proposal here is to prevent excessive capital gains to a select group of individuals through the expedient of nontransferable licensing. A final suggestion is to increase and change the structure of the license fees. The main intent here is to siphon off some of the excess returns that may be fueling investment and growth in the fishing capacity.[3]

With respect to the first set of proposals, the basic trend within the limited fleet was recognized quite early. In 1969 and early 1970, class "A" vessels when retired by an operator could be replaced on a boat for boat basis. In these 2 years, 76 vessels with a total carrying capacity of 186 tons were removed, and replaced by vessels with a total capacity of 596 tons. This clear subversion of the program's intent brought forth a rapid response. Effective July 1970, a "ton for ton" replacement rule was implemented, stipulating that the replacement vessel could be no larger in net tonnage than the vessel removed. If an operator wished to bring in a larger vessel, he could do so only by retiring additional vessel(s) up to the tonnage required.

In spite of this replacement rule the trend towards increasing capacity and capital intensity has continued unabated. Much of the downward trend in fleet size is actually due to the consolidation of smaller vessels into larger ones. Clearly, there are still too many loopholes. However, whether additional regulations (on vessel replacement or on the transition to multiple gear or species operations, for example) would be effective is questionable. The number of factors that define a vessel's catching capacity is infinitely large, and this type of regulation to be effective must eventually control all of these factors. The addition of one or two constraints may have a beneficial short run effect, but in the long run new loopholes will arise. The inevitable result would be an ever-expanding set of regulations of dubious value.

The perceived advantage of nontransferable licensing is that all "fishermen," both present and future, could share in any benefits from the licensing program. However, under the surface there are a number of significant problems. First, as already noted there would be a problem of exit for current operators. Without the ability to transfer the salmon license, older operators may be inadvertently forced to continue fishing. Clearly, this problem would necessitate some form of "buy-back" program. On the other side, there would be the eventual problem of entry. As attrition reduced fleet size over the years, inevitably new licenses must be issued. There would be an immense administrative problem involved in designing a system for equitable allocation among the numerous applicants, and it is questionable whether a government-designed system could be any more equitable than the current allocation of the market. As noted by Crutchfield (1979), "efficiency in use, continuity of operation and ease of administration are eloquent arguments for a relatively free and costless transferability of licenses."

The final proposed solution to the various problems with the program is perhaps the most realistic. A change in the level and structure of the license fees has the potential to cut to the root of the problem. The main driving force behind the increasing capitalization in fishing vessels and growth in fleet capacity lies in the value of the resource in relation to the short run costs of exploitation. In years of general price advance or bumper salmon runs (such as 1973 in British Columbia) a spread is created between resource value and catching costs. The resulting excess return is the basic fuel that drives the investment machine. An effective license fee system can constrain the growth in fleet capacity and fishing costs by appropriating a part of these excess returns.

The current license fees in the salmon fishery are clearly inadequate; they are flat rate and have remained unchanged since 1972. As a consequence, the dramatic increase in resource value over recent years has been allowed to remain within the fishery and with the inevitable results. A substantial increase in license fees and a general transition towards a resource value based fee, such as a landings royalty, would be an effective step in the right direction. Also, a further advantage of such a change often unrecognized is the potential impact on the level of license prices. Since the value of a license reflects the level of rent accruing in the fishery and expectations regarding future rents, increased appropriation by government will put a downward pressure on license values. This in turn will reduce the capital gains accruing to the original licensees. While in overall terms the new entrant would gain nothing, it can be surmised that an increased annual license fee will be preferable to a much larger lump sum capital payment.

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[3] The intent of this section is to examine only those measures that have been proposed to, and seriously considered by, Fisheries management. As a consequence, one interesting alternative is left unexamined. An individual catch quota system as outlined by Scott (1979) has much to recommend itself.

Conclusion

The year 1969 in British Columbia marks a significant transition in fisheries management policy. While the biological goals of regulation were still considered important, an economic dimension was added to the scheme of things. The salmon license limitation program has been an attempt to promote a strong and economically viable fishery, not only to protect the resource, but to ensure that its exploiters and its ultimate owners (the people of Canada) obtain a maximum benefit from it.

In regard to these objectives, the program implemented has several significant failings. First and foremost, the limitation program has failed to reduce the real costs of fishing in any absolute sense. The reduction in fleet size has simply called forth significant increases in the capital intensity of the remaining vessels. The consolidation of smaller vessels into larger vessels, the transformation from single to combination gear and species operations, and the addition of new although in a global sense unnecessary equipment throughout the fleet; each has played a role in the intervening years. A part and probably a large part of the potential economic benefits from the licensing program are being, and have been, dissipated in this manner. In addition, the current fleet in terms of catching power and capacity is far greater than in 1968, implying greater pressure on the resource base. Rather than decreasing the need for closed seasons, gear and area restrictions, the traditional management tools, these restraints have intensified even further.

In spite of this, however, the program may be a qualified success. The evidence of continuing positive license values indicates that some long run break has been initiated between fishing revenues and costs. The eventual equilibrium may be at somewhat lower capacity and cost levels than in a free entry situation. However, with respect to the distribution of any benefits, license revenues are a small and declining proportion of total management costs in this industry. Clearly, the public purse has not been a major beneficiary of limited licensing. At the same time, there is little reason to believe that fishermen *properly defined* will gain from the program. The real and only beneficiaries appear to be a select group of individuals who were licensed in 1969.

If one lesson is to be drawn from the British Columbia experience, it is that limited entry is not enough. The creation of a license, in itself, does nothing to prevent the destructive pattern of competition among fishermen for a share of the limited resource; it merely restricts that competition to an identifiable group of individuals. To effectively protect the resource base and create a more efficient industry, additional supporting measures are necessary. It is unfortunate that one of the most practical proposals in this regard is the least politically attractive. As always the management of fisheries is a sensitive issue, and it cannot be expected that fishermen will view higher license fees as a panacea. However, other alternatives appear to be ineffective short-term measures. As with the more traditional measures to protect the resource base (area, time, and gear regulations) they address the symptoms and not causes of the problem.

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Statistical Appendix

The following tables outline some of the major trends in the salmon fleet noted in the preceding text. The statistics presented are in several cases different from those in previous publications. An intensive review of the general licensing system for all British Columbia fisheries has just been completed under the direction of Dr Sol Sinclair. As part of this work an intensive edit of the data base was undertaken. The figures presented here should be taken as generally superseding those given previously.

TABLE 1 Trends in licensed salmon fleet 1969–77 (number of vessels). (Annual Licensing Statements – Fisheries and Marine Service, Vancouver, unpublished data.) These figures include a few vessels each year under construction or re-fit for which license fees are paid but that are not physically able to participate in fishing.

Year	"A"	"B"	Total licensed
1969	5870	1062	6932
1970	5668	973	6641
1971	5346	979	6325
1972	5001	897	5898
1973	4883	734	5617
1974	4799	697	5496
1975	4759	642	5401
1976	4700	623	5323
1977	4703	597	5300

TABLE 2. Gear category breakdown of the active salmon fleet 1967–77 (number of vessels) (Sinclair 1979). The phenomenon of combination gear and species operations requires a consistent classification system. The one used here is as follows: Any vessel that uses salmon seine gear and any other is classified as a seine combination; any vessel that uses salmon gillnet gear and any other (except salmon seine) is classified as a gillnet combination; any vessel that uses salmon troll gear and any other (except salmon seine or gillnet) is classified as a troll combination. Each year a small but indeterminate number of vessels are categorized as trollers but do not actually participate in salmon fishing. This gear can be used for other species.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Seiners	232	271	286	293	253	247	228	233	230	226	221
Seine combination	181	120	84	132	152	146	228	255	242	283	293
Subtotal	413	397	370	425	405	393	456	488	472	509	514
Gillnet	2041	2146	2462	2307	2144	2065	1798	1944	1690	1562	1524
Gillnet combination	1749	1614	961	1189	1071	957	1151	1024	1198	1294	1308
Subtotal	3790	3760	3423	3496	3215	3022	2949	2968	2888	2856	2832
Troll	2187	2217	2211	2138	2046	1957	1580	1563	1540	1602	1708
Troll combination	126	132	126	128	141	131	209	245	230	279	322
Subtotal	2313	2349	2337	2266	2187	2088	1789	1808	1770	1881	2030
Total	6516	6506	6130	6187	5807	5503	5234	5264	5130	5246	5376

TABLE 3. Trends in selected average vessel characteristics by gear type (selected years) (Sinclair 1979).

	1968	1971	1974	1977
Seine[a]				
Length	52.4′	53.8′	56.7′	57.7′
Gross tonnage	48.7	43.4	45.3	49.0
Net tonnage	26.8	28.0	31.3	29.7
Engine H.P.	162	174	194	232
Gillnet[a]				
Length	31.1′	32.3′	33.1′	33.1′
Gross tonnage	6.2	6.8	7.9	8.6
Net tonnage	4.9	5.3	6.1	6.1
Engine H.P.	109	128	146	160
Troll[a]				
Length	32.9′	34.9′	36.2′	36.5′
Gross tonnage	9.9	10.4	11.6	12.3
Net tonnage	7.0	7.6	8.3	8.2
Engine H.P.	85	96	104	116

[a] Single plus combination categories.

TABLE 4. Estimated nominal and real capital employed in salmon fishing (selected years — $ millions). (Fraser 1977; Income by Gross Return Group — Unpublished Summary Computer Run, 1976 and 1977.)

	1967	1968	1969	1973	1974	1975	1976	1977
Estimated fleet market value	68.1	72.9	80.1	117.7	219.3	204.2	241.7	273.0
Estimated license adjustment	0	0	0	12.4	79.0	43.3	UE[b]	UE[b]
Nominal capital employed	68.1	72.9	80.1	105.3	140.2	160.9	UE[b]	UE[b]
Real capital employed[a]	70.5	74.1	80.1	90.1	104.5	109.5	UE[b]	UE[b]

[a] Adjusted by Statistics Canada Boat Building and Repair Index: 1969 = 100.
[b] Unevaluated.

TABLE 5. Salmon landings by species 1968–77 ('000 lb round weight). (Annual Summary of British Columbia Catch Statistics. Department of Fisheries and the Environment, Pacific Region.)

Year	Spring	Sockeye	Coho	Pinks	Chums	Total landings	($ 000's) landed value
1968	15 237	41 390	33 381	55 600	36 510	182 118	44 887
1969	14 224	24 138	17 618	13 827	13 397	83 204	27 810
1970	14 474	25 186	30 091	52 960	36 972	159 683	45 076
1971	19 184	38 203	31 068	38 866	11 947	139 268	44 476
1972	18 413	20 982	23 221	39 994	66 562	169 172	50 341
1973	16 659	47 457	24 802	29 335	72 228	190 481	99 998
1974	16 836	47 826	22 880	24 706	27 512	139 760	73 998
1975	16 070	12 524	17 056	22 574	11 880	80 104	46 913
1976	17 142	27 202	20 551	37 602	24 079	126 576	91 942
1977	16 583	38 333	21 730	54 505	13 299	144 450	108 725
10-yr avg	16 482	32 324	24 240	36 997	31 439	141 392	63 417

TABLE 6. Trends in landed values of major species 1967–77 ($000's). (Annual Summary of British Columbia Catch Statistics. Fisheries and Environment Canada 1967–77.)

Year	Salmon	Herring	Halibut	Other	Total
1967	36 001	1 828	5 068	5 154	48 051
1968	44 887	231	5 628	4 972	55 718
1969	27 810	221	11 578	4 956	44 565
1970	45 076	290	7 242	4 301	56 909
1971	44 476	556	5 214	5 418	55 664
1972	50 341	2 726	9 373	8 377	70 817
1973	99 998	10 951	7 348	8 762	127 059
1974	73 998	12 043	4 746	9 495	100 282
1975	46 913	13 267	7 055	9 376	76 611
1976	91 942	23 442	11 974	11 462	138 820
1977	108 725	32 500	11 207	15 473	167 905

Impact of Canada's Pacific Salmon Fleet Control Program[1]

PETER H. PEARSE

Department of Economics, University of British Columbia, Vancouver, B.C. V6T 1W5

AND JAMES E. WILEN

Institute for Environmental Studies, University of Washington, Seattle, WA 98195, USA

PEARSE, P. H., AND J. E. WILEN. 1979. Impact of Canada's Pacific salmon fleet control program. J. Fish. Res. Board Can. 36: 764–769.

The available statistical data are analyzed to appraise the success of Canada's Pacific salmon fleet rationalization program, in terms of the extent to which it has prevented fishing costs from rising in pace with the value of the catch. It is found that while the fleet's revenues increased at about the same rate before and after the scheme was introduced in 1969, the real capital employed increased more slowly under the controls than earlier. The program has, nevertheless, failed in its purpose of preventing further expansion of redundant capital in the fleet. The reasons for this failure, and for certain apparent shifts in the structure of the fleet, are discussed.

Key words: Pacific salmon fishery, capitalization, economic rationalization, resource rent

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À l'aide d'une analyse des données statistiques disponibles, nous évaluons le programme de rationalisation de la flottille de pêche de saumons du Pacifique en fonction de son succès à empêcher les coûts de la pêche à augmenter au même rythme que la valeur des prises. Nous constatons que, alors que les revenus de la flottille ont augmenté à peu près au même rythme avant et après l'introduction des mesures en 1969, le capital réel investi augmenta plus lentement sous le régime des contrôles qu'auparavant. Néanmoins, le programme n'a pas réussi à empêcher l'expansion de capitaux redondants investis dans la flottille. Nous analysons les raisons de cet échec et de l'évolution de la structure de la flottille.

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IT is now almost a decade since the government of Canada introduced its pioneering fisheries rationalization scheme involving restrictive licensing of the Pacific salmon fleet, and the fishery's evolution under the new controls has attracted intense interest among both participants in the industry and policy-makers in Canada and elsewhere. In the developed fishing nations at least, there is now widespread recognition among fisheries authorities of the need to regulate access to commercial stocks if the potential economic value of the natural resource is to be realized. Moreover, under the impetus of enormous extensions of coastal states' fisheries jurisdictions and associated reorganization of fisheries policies, many nations are now urgently designing new institutional arrangements for regulating access. For these reasons the meagre experience with such policies, in which Canada's Pacific salmon fleet program is among the earliest comprehensive examples in the western world, is being studied with keen interest.[2] This paper examines the available evidence to throw some light on the efficacy of this important attempt at fisheries rationalization and offers some explanation of the changes it has induced.[3]

The salmon fishery is easily Canada's most valuable fishery, yielding a catch with a landed value in the order of $100 million in recent years. For several decades the stocks have been managed to provide the maximum sustainable yield, and while the catch statistics thus reveal no clear long-term trend they, nevertheless, fluctuate widely from year to year because of, inter alia, the varying life cycles of the five species of anadromous

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[1] This paper forms part of the Proceedings of the Symposium on Policies for Economic Rationalization of Commercial Fisheries held at Powell River, B.C., August 1978.

[2] For a compendium of restricted access schemes currently in place in various fishing nations see McKeller (1977).

[3] This study was facilitated by research assistance from F. Blasetti and M. Eswaran. We are grateful, also, to several industry personnel who provided valuable unpublished data, and to officers of the Department of Fisheries and Oceans, Pacific Region, who helped in providing access to statistical records. The analysis and presentation have benefited from comments on an earlier draft presented at the symposium, and from the criticism of two anonymous referees.

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salmon.[4] Under traditional unrestricted entry, the fishery can be assumed to have been constantly gravitating toward an equilibrium in which the costs of fishing adjusted (through entry to and egress from the fleet) to the value of the harvest, thus eroding potential resource rents.[5]

This condition of "bionomic equilibrium" is characteristic of most mature fisheries, where open access and common property combine to provide incentives to expand the fleet whenever resource rents emerge and are left to fishermen to appropriate as profits.[6] But the economic waste associated with this state is especially conspicuous in the salmon fishery because this species is highly valued and is technically capable of being caught at very low cost as the stocks converge on the gauntlets leading to their spawning channels.

For many years, the stocks have been protected from overfishing by a host of restrictions on efficient gear, seasonal closures and other controls which increase the cost of harvesting the regulated catch. Since the labor and capital employed in the fishery is several times that which is technically necessary, the potential gains from a rationalized industrial structure are substantial and undoubtedly greater than in any other Canadian fishery.[7] For these and other reasons the salmon fishery was a logical candidate for the first attempt at rationalization, and Canada's Pacific salmon fleet control program was introduced in late 1968 to become effective for the following fishing season.

Purpose and Method of the Controls

The lengthy background to the introduction of the fleet control program, the details of the way it was introduced, and the changes that have since been made in its structure, are documented in the preceeding paper by Fraser and need not be repeated here.[8] Some comment on the expressed purpose of the scheme is warranted, however. When first introduced, the controls were announced as "Measures to increase the earning power of British Columbia salmon fishermen and to permit more effective management of the salmon resource by controlling the entry of fishing vessels into the fishery . . ." (Minister of Fisheries 1968). This apparent concern with the *number* of vessels is important, and undoubtedly influenced the choice of regulatory instruments. All vessels that had recorded a significant catch in either of the preceding two seasons were declared eligible for a permanent salmon fishing license, subject to certain fees and conditions, including continuing fishing.[9] The fleet was thus frozen at 5870 permanently licensed vessels, but the licenses were transferable and the vessels replaceable. Within 2 yr it was recognized that limiting vessel numbers would not control expansion of fleet capacity, as 76 vessels were replaced with vessels averaging more than 3 times the tonnage of those retired — a trend that economic theory would predict.[10] Attention thus turned to controlling fleet *capacity*; net tonnage was chosen as the surrogate for capacity, and the new rule stipulated that any new vessel could replace only a vessel or vessels of equal net tonnage. The "ton-for-ton" replacement rule meant that a license effectively conveyed a right to employ a prescribed tonnage in the fishery, and thus the dimension of the fleet that has since been the subject of limitation is its aggregate tonnage.

The fishing capacity of a vessel is manipulable, of course, even within a net tonnage constraint, and the capacity of the fleet undoubtedly can be (and has been) increased without a corresponding increase in net tonnage.[11] However, there is an even more fundamental problem: the ultimate source of economic waste in commercial fisheries is neither excessive numbers of vessels nor excess capacity per se, but rather the use of too many inputs — labor and capital. Thus, it is in terms of *reduction in the real costs associated with redundant inputs* (however they may be combined in fishing units) that the success of a program of economic rationalization must ultimately be measured.

Ideally, then, one would evaluate the success of the salmon fleet control program by determining whether the real costs of fishing have been reduced, or at least restrained from increasing in proportion to the value of the catch, thus revealing whether the scheme has

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[4] For example, the 1974 catch of 140 million lb fell to 80 million the following year, and in 1976 rose to 127 million lb. Locally, the five species of salmon are described as sockeye, pink, chum, chinook, and coho. They are caught as they approach freshwater spawning streams at the end of their life cycle, which varies from 2 to 5 yr.

[5] The meagre returns earned in the fishery before restriction of access is documented by Campbell (1971). In view of subsidies and transfers to the fishery, and the significant costs of public management, the net social gain in this condition of long-run equilibrium was almost certainly negative.

[6] The concept of "bionomic equilibrium" is not entirely appropriate in this case, although it is customarily applied. The term properly refers to the joint adjustment of the stock (and yield) and fishing effort. Here, the yield was regulated, and only the fleet was left to adjust. But the process has the same effect in dissipating resource rents.

[7] Ten years ago, Crutchfield and Pontecorvo (1969) estimated that as much as 50% of the licensed gear in the B.C. salmon fishery could be removed without appreciable reduction in effective fishing capacity.

[8] See also Pearse (1972) and Fraser (1977).

[9] Ignored here are certain temporary provisions made for 1062 vessels that recorded a very small catch in the preceding seasons, and in total accounted for about 1% of the catch (see Fraser 1977).

[10] Some years earlier, Scott (1962) had predicted that such changes in the composition of fishing units would result from limiting vessel numbers.

[11] The measurement of net tonnage is complicated, and not always consistent; vessels can be redesigned to increase catching power with a fixed tonnage; and a large vessel may have greater catching power than two or more smaller vessels of the same tonnage (see Fraser 1977).

TABLE 1. Changes in the salmon fishery, 1960–76.

		Fleet revenue (millions $)				Vessels — no. and (%) combination			
Year	Landings[a] (million lb)	Landed value	Bonuses[b]	Total	Men employed[c] (no.)	Seine	Gillnet	Troll	Total
1960	75.15	18.40	.102	18.50	—	—	—	—	—
1961	121.63	26.63	.291	26.92	—	—	—	—	—
1962	163.91	30.56	.513	31.07	—	—	—	—	—
1963	119.32	22.79	.513	23.30	—	463 (40)	3851 (26)	3162 (6)	7476
1964	124.20	30.24	.855	31.10	—	428 (37)	3678 (27)	2989 (4)	7095
1965	90.19	25.96	.886	26.85	—	—	—	—	—
1966	162.85	38.65	1.779	40.43	9623	403 (38)	3691 (31)	2481 (4)	6575
1967	133.17	36.00	1.875	37.88	9747	414 (44)	3867 (38)	2358 (5)	6639
1968	176.36	44.89	2.890	47.78	9634	398 (30)	3828 (35)	2377 (6)	6603
1969	79.04	27.81	2.142	29.95	8912	369 (9)	3426 (28)	2341 (5)	6136
1970	154.49	45.08	4.053	49.13	9273	426 (31)	3504 (34)	2271 (6)	6201
1971	132.37	44.48	3.999	48.48	8709	405 (37)	3215 (33)	2186 (6)	5806
1972	164.39	50.34	4.527	54.87	8347	395 (37)	3046 (31)	2083 (6)	5524
1973	185.20	99.99	25.900	125.99	8270	512 (61)	3131 (51)	1594 (10)	5237
1974	134.25	73.99	6.200	80.20	8514	526 (62)	3120 (47)	1564 (11)	5210
1975	76.17	46.91	4.900	51.80	8111	—	—	—	—
1976	121.80	91.94	11.700	103.60	—	—	—	—	—
1977	138.35	108.72	13.400	122.10	—	—	—	—	—

[a] From Department of the Environment (1977).

[b] From F. Blasetti (unpublished data) based on confidential sources made available to the authors.

[c] From Faser (1977).

driven a wedge between costs and revenues and allowed some of the potential economic rents to be realized. Unfortunately, such a test is fraught with complications, among them the large fluctuations in physical yields and prices during the short history of the program, rapid technological changes (some induced by controls), and the wide variation in the opportunity cost of the manpower and capital employed.[12] Nevertheless, the available evidence permits certain broad deductions.

The declared purposes of the program, cited above, are twofold. One, the distributional objective of improving fishermen's incomes is not dealt with in detail here. Instead, attention is focused on the second objective (on which the success of the first inevitably depends), namely whether entry into the fishery, in terms of the value of labor and capital employed, has been restricted.

Based on a priori analysis of the program shortly after it was introduced, one of the present authors speculated that the licensing system would hasten the substitution of capital for labor in the fishery, that it would discriminate against the labor and capital with lowest opportunity costs, and that it might prove inadequate to stem expansion of redundant fleet capacity and capital employed (Pearse 1972). More recently, Fraser (1977) examined the changes in the fleet since the scheme was introduced; he concluded that it had not succeeded in checking capital expansion and, indeed, capitalization may have proceeded at an even faster rate than would have been expected under continued free entry. Here, new data and a somewhat different technique are used to reexamine the experience, and a rather different explanation for the observed trends is suggested.

Trends in the Fishery

The salmon fishery, and particularly the structure of the fleet, have undergone significant change, both before and after the rationalization program was introduced. The most salient of these trends, summarized in Table 1, are

i) The value of the catch has fluctuated widely over a generally rising trend. Most of the year-to-year fluctuations (but not the trend) are due to changes in the level and composition of the catch. Prices have risen significantly, though irregularly. Estimates of the total amount of unrecorded year-end bonus payments paid to vessel-owners, which have been added to the reported landed value of salmon to indicate the total revenues of the fleet in Table 1, contribute to the rising trend.

ii) The number of men actively employed in the salmon fishery has steadily declined.

iii) The number of vessels active in the fishery has steadily declined.

iv) The composition of the fleet has changed

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[12] Other important complications relate to the influence of changing earnings of the salmon fleet from the herring and other complementary fisheries, the rate of depreciation of vessels and gear, the significance of vessel-owners' expectations about the success of the control policies in determining their investment behavior, and the effects of the share system of remuneration in certain sectors of the fleet.

TABLE 2. Estimated values of salmon licenses, vessels, and gear, 1966–77.

	Millions $		
Year	Reported value of vessels, gear, and licenses[a]	Estimated value of licenses[b]	Estimated value of vessels and gear
1960	37.08	—	1960–72 as in column 1
1961	38.86	—	
1962	40.93	—	
1963	53.82	—	
1964	51.15	—	
1965	55.80	—	
1966	60.64	—	
1967	68.07	—	
1968	73.47	—	
1969	80.70	0	
1970	89.18	0	
1971	82.84	0	
1972	93.71	4.11	89.6
1973	133.30	13.30	120.0
1974	219.26	86.96	132.3
1975	204.24	78.14	126.1
1976	214.65	58.66	182.99
1977	277.65	78.12	199.53

[a] From F. Blasetti (unpublished data).
[b] From data assembled by the authors.

markedly. The sharpest decline in numbers has been in the troll category, while gillnet vessels have fallen slightly and seiners increased somewhat. In all categories there has been a marked shift from single-gear to combination-gear vessels. The trends in the capital value of vessels and gear and in the market value of licenses are summarized in Table 2.

Evaluation

To draw inferences from these data about the success of the fleet control program, we assume that the fishery was in or near a state of bionomic equilibrium before entry was restricted, and would have remained so in the absence of these controls. Success is to be measured in terms of any emerging spread between fleet revenues and fishing costs. Whether the scheme has been successful thus depends on whether the aggregate real opportunity costs of the labor and capital employed have risen at a slower rate, since 1968, than the revenues of the fleet.

We can observe from Table 1 that the labor engaged in the fishery decreased by about 16% between 1968 and 1975. Hence it is reasonable to conclude that the real costs of labor, at least, have not risen.[13] We thus turn our attention to the cost of capital. If the value of capital engaged in the fishery has not risen, or has risen less than revenues, we can conclude that rents have emerged. Only if capital costs have increased faster than revenues must we conclude that the evidence on rents is unclear, because then the growth in capital costs could fall short of, match, or exceed the gains from lower labor costs.[14]

To compare the trend in the capital employed to the trend in the fleet's revenue, we first adjusted published data on the aggregate value of the fleet, as shown in Table 2. These published data (in the first column) are compiled from license renewal forms completed annually by vessel owners, on which each applicant is asked to estimate the value of his vessel; this is normally interpreted as the composite value of the vessel, gear, and license.[15] From these estimates we subtracted the aggregate value of licenses in each year (in the second column) to obtain an estimate of the value of vessels and gear in the fleet (in the third column).[16] These estimates of real capital employed were then deflated to 1971 dollars and the resulting series used to calculate the trend in capital growth over the relevant period.[17] This trend was then compared with a similarly deflated series of total fleet revenues over the same period (from Table 1).

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[13] This conclusion involves an assumption that the opportunity cost of labor, per unit, has not risen; or at least not sufficiently to offset the decline in the amount of labor engaged in the fishery. Blasetti (unpublished data) calculated that between 1969 and 1977 the number of man-days spent in fishing fell by 8.2%.

[14] A more thorough analysis of costs would account for, in addition to labor and capital costs, running costs and repairs and supplies. We implicitly assume that these costs are proportional to the capital value of the fleet or, less restrictively, that they have not risen more rapidly than capital values.

[15] To test the reliability of these reported values we drew a random sample of 65 vessel transfer forms relating to vessels sold in May, June, and July of various years and compared the actual sale price with the corresponding owner's estimated value on his March renewal form. An ordinary least-squares regression of sale values against reported values reveals a high correlation:

$$\text{sale value} = \underset{(1.88)}{3642} + \underset{(21.34)}{.98}\ (\text{reported value})$$

with an $R^2 = .879$ and t-statistics as shown in parentheses. We are thus confident that the reported values are reasonably accurate indicators of market value.

[16] Information about the market values of licenses in each year was obtained by the authors from agents who have been active in transactions in salmon vessels and licenses throughout the period.

[17] We are grateful to J. Crutchfield for drawing our attention to possible bias in our estimates resulting from quasi-rents in vessels. In the short-run, rapidly rising fish prices could result in rents being capitalized in the vessels themselves, as distinct from license values. This would bias upward our estimate of real capital employed in the relevant years. However, for this to substantially affect our findings about the trend in growth of real capital, the implied disequilibrium would have to be persistent, if not increasing, over the whole period. It seems unlikely that capital adjustments in the industry are so slow that this would significantly influence the observed trend.

For both series — the value of capital employed and fleet revenues — the rates of growth from 1957 to 1977 were calculated by regressing their natural logarithms against an index of time. For fleet revenues the estimated equation is

$$\ln(\text{fleet revenue}) = \underset{(79.38)}{10.253} + \underset{(4.04)}{0.044 \cdot t}$$

$$n = 20 \qquad R^2 = .48 \qquad D.W. = 2.07$$

The trend, indicated by the time index coefficient (t-statistics are shown in parentheses), suggests that the fleet's revenues grew at an average annual rate of 4.4% over the period. In view of the substantial short-run fluctuations in catch and prices, the fit appears reasonably good, and there is no evidence of autocorrelation. Moreover, tests revealed no evidence of different rates of growth before and after 1969, when the program was introduced.

The equation for capital growth takes a similar form. However, to test whether different rates of growth could be discerned before and during the control program, a dummy variable (D_t, given a value of 1 in the program years and 0 in others) was included as an explanatory variable. Also included was a variable for the current harvest value, H_t, to eliminate any quasi-rents associated with large harvests. The resulting equation is

$$\ln(\text{fleet value}) = \underset{(242.47)}{10.529} + \underset{(2.04)}{0.239 \cdot D_t} - \underset{(2.39)}{0.020 \cdot D_t t} + \underset{(2.71)}{0.250 \times 10^{-5} \cdot H_t} + \underset{(11.15)}{0.057 \cdot t}$$

$$n = 20 \qquad R^2 = .99 \qquad D.W. = 2.09$$

This evidence reveals a statistically significant difference in the rate of capital growth during the two phases: an average annual rate of 5.7% before 1969 and 3.7% thereafter.

This admittedly rough evidence suggests that the fleet rationalization scheme has been partially successful in checking the expansion of capital engaged in the fishery. More important, however, is the clear evidence that the growth in redundant capital has not been halted. As observed earlier, the fleet's capacity was far in excess of the fishery's needs when the program to control its further expansion began; but it has continued to grow (indeed, in view of technological advances, fishing power has almost certainly grown faster than the value of capital employed). However, the rate of capital accumulation appears to have been slower under the controls, even though the fleet's revenues continued to grow roughly as before, and this may be allowing some resource rents to be realized. The market value of licenses may reflect these emerging rents, but since the current value of fishing privileges reflects expectations of *future* returns in fishing, this is not conclusive evidence that rents are currently (or ever will be, for that matter) realized.

Further Observations

Several implications of the rationalization program deserve comment in light of these conclusions. The changing structure of the fleet is of considerable interest in itself, and raises the question of whether the shifts in gear types — toward combination-gear vessels and the more capital-intensive seine vessels — can be regarded as trends toward a more efficient fleet. Obviously, there can be no improvement in efficiency in the aggregate sense as long as the shifts do not contribute to the total catch; but leaving this aside, we have no data on which to base any assessment of the relative efficiency of the three gear types since the catch is allocated among them by the regulatory authorities according to vague notions of equity.[18] Thus it is possible that the smaller, single-gear and older fishing units that are being eliminated from the fleet may be the most efficient in terms of their cost of catching fish.[19] Indeed, the form of the restrictive licensing creates a clear financial incentive to economize on tonnage, which is not likely to lead to the choice of gear that minimizes aggregate costs. Thus, for example, if seine vessels can earn more per ton than can trollers, licenses can be expected to gravitate toward the seine sector to a greater extent than is economically efficient, and this distorting influence may explain some of the shifts in fleet structure that are being observed.

Another trend of some interest is the growth in importance of bonus payments to vessel-owners. These are payments made by the packing company to the vessel-owners who deliver their catch to that company; they are post-season, lump-sum payments which are not normally shared with the crew as are the immediate payments for landings. These rising bonus payments are almost certainly linked to the increasing capitalization of the fleet and reflect the inflexibility of the traditional share system in the face of changing proportions of labor and capital costs. In effect, bonuses are a means of increasing payments to the owners of capital, by circumventing rigid sharing of revenues from landings, as the fleet becomes more capital-intensive.

Finally, in light of the observation that the program has apparently failed in its purpose of preventing further accretion of redundant capital in the fleet, some comment is necessary on its shortcomings. Fraser (1977, p. 61) suggests that "The basic problem is the excess returns left in the fishermen's hands." He argues that any increase in income associated with rising catch values accrues to vessel owners who have every incentive to invest it in larger vessels and more gear, and concludes that this fueling of investment can be alleviated only by governmental levies that will appropriate rising resource revenues and thereby make them unavailable for fleet expansion.

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[18] The report of the West Coast Salmon Fleet Development Committee (1973) recommended studies of the relative efficiency of the several types of gear used in the fishery. As far as we are aware, this recommendation has not been pursued.

[19] Thus Pearse (1972) argued that the rationalization program, by eliminating the smaller, older, and "less productive" units, and their associated crews, may well eliminate those factors with the lowest opportunity cost in catching salmon.

We are less confident about this solution. It is true, of course, that if the government put such high charges on fishermen that they, and their capital, earned less than they could in other industries, some labor and capital would be driven out of the fishery. But as long as it is profitable to increase fishing power at the margin by adding capital, fishermen will have an incentive to do so regardless of the amount they have paid for their license, and whether their incomes are high or low. Governmental charges may alter the amount of capital of their own they have to invest, but with ready access to banks and other lending institutions fishermen's investment behavior will be influenced much less by their liquidity than by their expectations of returns to capital, and the latter has not been diminished by the control program.

Our conclusion, instead, is that because the program restricts only one flexible dimension of fishing effort — tonnage — it distorts but does not limit the employment of capital, and since it leaves intact all the incentives to dissipate resource rents through expansion of inputs that exist in competitive open-access fisheries, it cannot be expected to contain fleet capitalization. Any attempt to ameliorate the basic economic problem of excessive employment of labor and capital in fisheries which depends on restricting inputs must restrict simultaneously all dimensions of effort, or at least sufficient of them that they cannot accommodate substantial expansion of unrestricted factors. In view of the flexibility of technology, in semiindustrial fisheries especially, and of the enormous variety of dimensions of fishing effort, we suspect that a successful rationalization program of this type would be so complicated as to be unmanageable.

Alternatively, a levy on the catch (as opposed to a fixed charge like a license fee) would lower returns to incremental additions to catching power and thereby reduce incentives to overcapitalize the fleet. But to eliminate perverse incentives to expand fishing power inefficiently, the levy would have to reduce fishermen's anticipated net returns to zero at the margin. This would present fisheries authorities with the formidable, if not impossible, econometric and administrative task of determining the "correct" levies for different species, sizes, and locations and constantly readjusting them in response to changes in costs and prices.[20]

A much more promising approach in our view is one that eliminates the incentives that create the problem; by converting the present licenses to engage in fishing to licenses to take specified quantities of fish (as is usual in allocating rights to most other public resources) fishermen would be left to discover the least-cost method of fishing and would have every incentive to do so. But exploration of this alternative is beyond the scope of this paper; for further discussion readers are referred to the papers by Maloney and Pearse and by Scott in this issue.

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[20] Systems of charges and their effects are discussed by Crutchfield in his contribution to this collection (see also Pearse 1978). Since this paper was written, the government of Canada has received recommendations involving, inter alia, a royalty on all landings of commercial fish on the Pacific Coast, initially set at 2% of the landed value (Sinclair 1978). While such a simple levy might accomplish certain revenue objectives, it is obvious that it would not go far as a means of regulating fishing effort.

Alaska's Experience with Limited Entry

A. ADASIAK

1835 Crescent Drive, Anchorage, AK 99504, USA

ADASIAK, A. 1979. Alaska's experience with limited entry. J. Fish. Res. Board Can. 36: 770–782.

The goals and structure of the limited entry program in Alaska were defined by the political, social, economic, and biological climates in which the program was implemented. This paper outlines how these considerations formed the program and discusses the impacts of the program and the problems involved in its implementation. Other possible modes of approaching entry limitation are discussed in relation to the possibility of limiting some currently unlimited fisheries.

ADASIAK, A. 1979. Alaska's experience with limited entry. J. Fish. Res. Board Can. 36: 770–782.

Les buts et la structure du programme concernant la limitation de l'accès aux pêcheries en Alaska ont été déterminés par les conditions politiques, sociales, économiques et biologiques qui prévalaient au moment de la mise en oeuvre du programme. Le présent document souligne le rôle qu'ont joué ces éléments dans la composition du programme et étudie les effets qu'aura ce programme ainsi que les problèmes qu'entraînera sa mise en oeuvre. En outre, on y étudie d'autres façons possibles d'aborder la question de la limitation de l'accès relativement à la possibilité de limiter l'accès à certaines pêcheries qui ne font pas l'objet de limitations en ce moment.

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Introduction

This paper will show what happens when one of the theoretical forms of limited entry — issuing licenses to a limited number of persons — is taken from the plane of conceptual consideration to a particular application. It will also attempt to abstract elements of broader relevance from the specific circumstances under which limited entry developed in Alaska. Three of those are obvious, yet easy to forget:

1. There is no form of limited entry that will satisfy everybody.
2. There is no single form of limited entry that is the right one for all situations. Rather, limited entry systems must be tailored to the particular fisheries, and the social and economic settings they are to be part of.
3. Different forms of limited entry will have different consequences. Because of that, it is important to work pragmatically, in the strictest sense, and to have as clear an idea as possible of the likely consequences of various limited entry alternatives.

THE FIELD OF ACTIVITY

Alaska's limited entry experience has directly involved approximately 15 000 entry permit applicants of diverse cultural and economic backgrounds, who have participated in commercial salmon and herring fisheries stretching along perhaps 20 000 miles of coastline and up the Yukon and Kuskokwim rivers. About two thirds of those applicants have received or will receive an entry permit. For various reasons, a number of other participants in those fisheries did not even apply for permits. Less directly, Alaska's limited entry program affects crew members, families, communities, and businesses related to fishing. It also affects all remaining commercial fisheries not under entry limitation.

The magnitude of program impact must be seen in the context of a state with a total population of about 405 000. In 1976 the total ex-vessel value of the catch to the part of the state's workforce who were fishermen in limited fisheries (nearly all salmon and some herring fisheries) was approximately $125 million. Another $118 million in ex-vessel value to fishermen was generated in currently unlimited fisheries during the same year, of which $97 million came from Alaska's shellfish fisheries.

LIMITED ENTRY — ONE DEFINITION

Limited entry is a member of the broader family of ideas categorized as "effort regulation," or "effort limitation" (Christy 1975). It works by fixing the number of participants in the harvest, whether the participant is an individual or a vessel. Such devices as quota shares and taxation have been referred to loosely as "limited entry," but they are more accurately other means for effort regulation that do not rely on directly limiting the number of participants in a fishery. The objective of all these devices is to stabilize the effort, but it is important to remember that none of them can produce miraculous results all by itself.

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A Paper for Certain Groups

This paper is directed primarily toward those policy makers and decision makers who may find themselves considering the application of limited entry to fisheries within their purview. Equally important, the paper is for fishermen and others who may be affected by limited entry. It reflects upon and generalizes from various aspects of Alaska's experience with limited entry; its purpose is to be both provocative and helpful.

The point of view is that of an implementer providing personal observations and conclusions arrived at after having been involved with Alaska's limited entry program since late 1971, which was before the formal beginning. That beginning was marked by the establishment of a study group in 1972 which conducted research and developed the limited entry bill introduced and enacted in 1973 (Governor's Study Group on Limited Entry 1973). My colleagues and associates should not be held responsible for these remarks.

The paper is impressionistic because of the complexity of the subject and because of the short span of actual fishery performance data available for analysis. In the best cases, only 2 yr of reliable data are available. The paper is also practical, pragmatic, and in a sense "political."

A detailed exposition of the mechanics of the program is not presented here. (The reference list in the appendix indicates available information on the program.) Instead an analysis of program goals and performances is followed by a discussion of some of the problems encountered, and of some future challenges.

Alaska's Program: A Capsule

Briefly Alaska's limited entry system makes an initial allocation of entry permits to individuals on the basis of a complex ranking system that balances various aspects of each individual's economic dependence and past participation in a fishery. Permits are issued to natural persons only and are freely transferable, although they may not be encumbered, used as collateral, or attached. Permits are issued by fishery and no fisherman may hold more than one permit per fishery. The term "fishery" has a special meaning, namely "the commercial taking of a specific fishery resource in a specific administrative area with a specific type of gear." Thus, for example, a fisherman may hold a salmon power troll permit for southeast Alaska and a salmon gillnet permit for southeast Alaska, but not two salmon gillnet permits for that area. However, he may hold a salmon gillnet permit for southeast Alaska and another one for Cook Inlet since the permits are for different administrative areas. Interim-use permits are required for the operation of gear in all commercial fisheries not under entry limitation. These permits are used to monitor fishery activity. Interim-use permits for these fisheries are issued to anyone with the present ability to participate actively in the fishery.

A Word on Words

Finally, incorporating limited entry into a fisheries management program brings social and economic objectives and considerations more toward the foreground, whether explicitly or implicitly. Consequently, terminology sometimes undergoes changes in meaning. For example, "allocation" to a fishery manager might mean either "catch versus escapement" or "distribution of catch among gear types." The distribution or allocation of the resource, however, also relates to the allocation of income, or considerations of access to the resource by different social and economic groups.

Similarly, "efficiency" can mean "harvest efficiency" or "economic efficiency." While the deliberate recognition of social and economic factors in fisheries management is laudable, more deliberate definitions of terms are also required to avoid misunderstanding.

Goals and Performance

Alaska's limited entry program has a number of goals dealing with economics, resource management, and social considerations. Some of these goals are explicitly stated in the state's limited entry law (AS 16.43 1977a); others can be inferred, and some have been assumed, though not often articulated. The nature of the goals has permeated through the program and has shaped the way it is implemented. Least explicit, perhaps, are the social considerations that interpenetrate things, though some may quibble whether they are "social" matters or matters of "economic welfare."

Shifting the Balance of Power

In Alaska we chose to issue licenses, which we call "entry permits," to individuals rather than to vessels. This was due in part to historic patterns of various salmon fisheries in our state. Traditionally, salmon fishing has been carried on predominantly on a one skipper–one vessel basis. Crew members were either part of the family or seasonal employees of the vessel owner or operator. In some areas, however, particularly where individual ownership was difficult, processors owned a larger number of vessels and hired fishermen for the season.

Although ownership and operating patterns were a major consideration, other reasons for issuing permits to individuals grew out of the history of the salmon-processing industry in Alaska.

In Alaska there had been a long history of domination of, or significant influence over, the territorial government by the canned salmon industry (Cooley 1963). With the advent of statehood and of a broader economic resource and commercial industrial base for the state, that influence has diminished. When the Alaskan legislature was considering the current limited entry law in 1973, there was a general belief that salmon processors still maintained a significant hold over individual fishermen, both through credit and financing arrangements and through the untrammeled power to decide whether a fisherman would fish for a particular company.

The decision to issue permits to individuals was made primarily because people believed that it would strengthen the individual fisherman's bargaining position vis-a-vis fish buyers and processors. With only a fixed number of permits to go around, and with the requirement that a unit of gear may be operated only by a permit holder, the need that the processor had for the individual fisherman was increased.

The legislature further decided to issue permits to natural persons only, prohibiting partnership or corporate ownership. It also restricted an individual to hold only one permit of a given type to prevent individuals from controlling and parceling out permits for a fishery. And it provided that an entry permit may not be pledged, mortgaged, leased, or encumbered in any way; transferred with any retained right of repossession or foreclosure; or attached, distrained, or sold on execution of judgment or under any other process or order of any court. To the extent that then seemed possible, that meant the permit belonged to the individual fisherman, and it made it extremely difficult to get it away from him against his will.

PERMITS TO INDIVIDUALS: SOME RESULTS

The results of issuing permits to individuals have not been researched, and some matters such as bank lending policies are not likely to yield to investigation, but here are my impressions:

— Industry fears that the balance of fishermen among competing companies would be seriously disturbed have proven unwarranted. The advantages of a steady market have provided a stabilizing effect. Beyond that, however, it is difficult to say what concessions and accommodations have been made by the processor on an individual or a group basis to maintain the desired levels of fishermen. The absence of visible dislocations and voluble complaints from processors suggests though that nothing too serious has happened.

Processor control of permits may not have been completely forestalled, but such control is indirect and probably of relatively low incidence. Direct financing of permits is prohibited by law, since they cannot be used as collateral then repossessed. Consequently, oblique methods are probably being used to finance other things or to lower operating costs in a way that allows the acquisition of permit. But, the realization that a fisherman can walk off, with his permit, and fish for someone else has probably inspired additional caution in those who would consider such arrangements. An Entry Commission survey indicates that some type of financing occurs in 50–90% of all permit transfers, depending on the fishery. Allowing for variations by fishery, sources in order of frequency generally are the transferor, banks, processors, state loans, and credit unions. In the case of banks, state loans, and credit unions, other collateral is almost always required.

— Conventional lending sources such as banks are using the entry permit as a major touchstone in deciding whether to grant loans. While money is rarely loaned directly to purchase a permit (I have heard of only one case), the permit is being accepted more and more as a solid indicator of earning power so that financing can be arranged for vessel improvements, new vessels, new gear, or other items. This allows fishermen to work more easily through conventional financing channels, causing them to rely less on processor financing. Even processors, of course, use the entry permit to decide whether to extend credit.

— The bargaining power of the fishermen in relation to the processors has increased, at least in the view of some fishermen who have engaged in price negotiations. The extent of the change varies from area to area, depending on such things as processor attitudes, the number of processors in an area, and the degree to which the fishermen are organized. One negotiator has attributed the higher price received for salmon in 1977 directly to limited entry and "the fact that they cannot replace us with somebody else." Another, recounting victories in 1977 price battles, said limited entry is "the best thing that ever happened to the fishermen."

This last matter could be interpreted to say that limited entry has driven up the price of fish. However, the ex-vessel price of fish in fisheries not under entry limitation in Alaska has also generally risen since 1973, as have fish prices elsewhere in the nation. Actually, market price (demand) is probably a much more important factor here, with limited entry increasing the margins to the fishermen.

The added bargaining strength given to the fishermen must be recognized as a force, but the fishermen must appreciate the limit of that force, taking inventories, market conditions, run sizes, and other factors into account. A series of banner years in fish returns can mean that some fishermen might not even find an outlet for their catch. Additionally, bargaining strength is limited by antitrust laws.

As an aside, members of the North Pacific Fishery Management Council and others involved in fisheries have noted that extended jurisdiction under the United States' Fishery Conservation and Management Act of 1976 (FCMA) provides, in effect, limited entry for foreigners. This allocation procedure may have international market ramifications affecting fish prices as well.

SOCIAL CONSIDERATIONS

Social objectives or considerations were prominent in the decision to issue entry permits to individuals rather than vessels. The social and cultural aspects of Alaska's fisheries were considered in other ways as well.

To begin with, the legislature considered and rejected proposals to issue permits to individuals strictly on the basis of their catch records, which would have put permits into the hands of only the better performers. A primary concern here was the effect such a system might have in some native villages where different cultural values and institutions sometimes resulted in relatively low catch levels. To remove less effective fishermen could deprive subsistance-oriented communities from a significant, though perhaps relatively small, amount of cash needed for the continued functioning of those communities.

MINIMUM SOCIAL DISLOCATION

Viewed more broadly, a tacit objective of establishing limited entry with a minimum of social dislocation can be identified. This helps to explain the complex set of issuance criteria set forth under AS 16.43.250. While the legal standards reflect social considerations, those are even more clear in the Entry Commission regulations for the salmon fisheries (20 AAC.05 1977b).

Social considerations are also reflected in the permit fee provision of the law that allows a low fee for applicants whose net family income falls within federal poverty guidelines, and in the 60-d waiting period mandated before a permit can be transferred. There was definite legislative concern that a permit holder, running short of cash in the depth of winter, might, especially after a few drinks, decide to ignore his long-term interest and sell his permit. Fishermen have made use of that provision to halt a transfer agreement that had been entered into.

The very issue of whether entry permits should be transferable or nontransferable was heatedly debated in the legislature and is still argued. One of the social values of those opposed to transferable permits is that initial permit recipients benefit from what is perceived as a windfall gain; this opposition is voiced even by some fishermen who received permits under the initial allocation. While there were other considerations, the primary social value that seemed to carry the case for transferable permits in the legislature was the desire of fishermen to be able to pass a permit on within their families, or to have the option of seeing that a crewman or friend received it. Reversion of a nontransferable permit to the state with reissuance by competitive bid or lottering seemed to pose the threat of too great a tear in the social fabric. Entry Commission survey figures indicated that in 1977, 29% of all entry permits were transferred without remuneration (87 vs. 302), suggesting that this social, nonpecuniary handling of permits is operative.

At the administrative level, the objective that limited entry be implemented with a minimum of social dislocation manifested itself in various ways. Briefly, some of those included an extensive public information program, more than 40 public meetings and hearings to obtain public input before the first set of regulations was adopted, a similar procedure for other fisheries limited subsequently, the use of application assistance programs, continued help in developing or perfecting evidence after applications are submitted, and a nonadversary approach by commission hearing officers.

Sensitivity to the social aspects of limited entry has made it easier to implement a program that creates a significant change in social and economic patterns.

THE "RICH MEN'S CLUB"

Combining limited entry, rising prices, and a few years of generally good salmon returns has provoked the first murmurs in Alaska of the charge that an exclusive "rich men's club" has been created. British Columbia heard that cry far more loudly a few years ago when, as I recall, the epithet was a "millionaires' club."

A few tempering observations are in order. It is easy for the uninitiated to forget during good years that salmon runs can fluctuate widely, and that the variables influencing these fluctuations are not all known, let alone currently controllable. Therefore, short-term judgments should be viewed with caution.

The uninitiated also tend to confuse gross returns with net returns, and the talk on the docks and in the bars always pivots around the highliner — seldom about the fisherman who barely scraped by or went bankrupt. In addition, a number of fishermen still practice something close to "cigar box accounting," not appropriately taking into account such things as opportunity costs of operating capital, investment, and entry permits. The result can be a ragged and imprecise picture of net returns.

Preliminary information from an Entry Commission 1977 cost and earnings study of the Prince William Sound salmon drift gillnet fleet does not show the existence of a "rich men's club." It shows in rounded numbers adjusted for an apparent bias in the sample an average gross of $18 600 and an average net return to labor and management of $8700 (Commercial Fisheries Entry Commission 1978, unpublished data). When workers on the Trans-Alaska pipeline were walking away with $40 000 to $70 000/yr, and considering Alaska's cost of living, that is hardly enough to precipitate justified cries of righteous indignation.

DEALING WITH "EXCESS" PROFITS

And yet, those familiar with Alaska's salmon fisheries will rejoin, "What about Chignik in 1977?" The Chignik purse-seine fleet is the new instant legend. Official information is not available yet, but preliminary estimates indicate that the average gross was approximately $200 000 and the high boat grossed about $500 000. Again, no one discusses net, just gross. And again, no one remembers the early 1970s, when the average gross earnings in 1972, to take the low end of the spectrum, were $12 573.

Still, the question that remains about Chignik, which is a legitimate one, is "what are you going to do about Chignik if things continue as they were in 1977?" More generally, the proposition is, does limited entry inherently allow the creation of an exclusive rich men's club? We have already begun asking ourselves that question, and fortunately we have a few years to work out the answer, which at the moment does not seem to be simple.

Part of the answer is to be measured in relation to one of the goals of Alaska's limited entry program. The state intended to create a climate that would encourage professionalization and diversification of the fleet. It takes money to upgrade, to make a boat more safe, to diversify, and take steps that encourage the development of markets. In evaluating significantly increased earnings in a fishery, it seems appropriate to consider the use to which the additional money is being put. Assuming the goal of a professionalized, diversified fleet is still desirable, general patterns of the application of increased capital may offset, at least to some degree, what on the face are "fat cat" incomes.

Beyond that, Alaska law (AS 16.43.300(9)(2)) provides that the Entry Commission may issue additional entry permits in a fishery (increase the optimum number of permits) if there is "an established long-term change in market conditions" which are taken broadly to mean "economic conditions." Presto! The solution. People are making more than "a reasonable average rate of economic return to the fishermen . . . , considering time fished and necessary investments in vessel and gear," (AS 16.43.290(1)) and based upon that optimum number criterion in our law, we issue more permits.

But, pursuing this feat in which the solution is produced, there may be an "Oops," in which we find that the rabbit will not quite come out of the hat. Another major criterion in establishing an optimum number of units of gear in a fishery is "the number of entry permits necessary to harvest the allowable commercial take of the fishery resource during all years in an orderly, efficient manner, and consistent with sound fishery management techniques" (AS 16.43.290(2)). Suppose the Entry Commission concludes that on the basis of economics the Chignik fishery can appropriately support 120 units of gear, rather than the current 92. However, because of technological innovation making the fleet more efficient, Alaska Department of Fish and Game fisheries managers say that 92 is still the upper limit that the Chignik fishery can stand before conventional management techniques break down and there is a serious risk of significant management error that could jeopardize the resource.

The numbers are illustrative only, but at the conceptual level we can anticipate the possibility of such a dilemma. Is the answer to increase the number of vessels, but regulate the fleet into far greater inefficiency? That appears to be inconsistent with the goal of a professionalized, diversified fleet. Various possible solutions must be explored, including some form of tax, since if the dilemma does not emerge in Chignik, it is likely to emerge somewhere else. Fortunately, the law requires "an established, long-term change in market conditions," which allows the variables in a fishery to work themselves out over time, allows presently unrecognized factors to become explicit, and allows an opportunity to develop the best possible solutions.

A PROFESSIONALIZED, DIVERSIFIED FLEET

The goal of a professionalized, diversified fleet is not stated in Alaska's law, although it can be read as implicit in the "economic health and stability" purpose of the law. That goal was openly discussed in the legislative process.

Once again, it is not possible to produce many study results measuring progress toward this goal, or the other goals of limited entry, due to a shortage of time and money for such work, and our limited experience with the program. However, power trollers generally assert that competition is keener than before limited entry. Prince William Sound fishermen sometimes wistfully look back for the days when fishing was somewhat more leisurely, noting especially that "those guys who buy their permits are really out there pushing." The trend state-wide appears to be to take fishing more seriously, to invest in better boats and gear, partly because of the sense of "owning" a piece of the fishery.

The number of fishermen holding more than one permit in both the limited and unlimited fisheries is increasing year after year, indicating a growing interest in diversification. Not only is diversification being made possible by greater profits and easier credit, it is also being encouraged by the fear of limited entry in presently open fisheries. Many fishermen feel they must move as quickly as possible to get into promising or desirable fisheries before the door is shut on them.

ECONOMIC HEALTH AND STABILITY

One of the stated goals of limited entry is to promote "the economic health and stability of commercial fishing . . ." (AS 16.43.010). It is easy to argue but hard to prove without formal studies and a longer period of implementation that limited entry is contributing to that goal. Perhaps a few indirect observations will be helpful.

Large salmon returns can hardly be attributed to limited entry, although it is probably safe to say that public support through bonding for hatcheries and legislative support for rehabilitation programs would not be nearly as strong without limited entry. The voters generally recognize that it makes little sense to increase fish returns by 30% if the number of units of gear engaged in the harvest is free to go up by 40%. Similarly, the Alaska legislature probably would not have passed a nonprofit hatchery act (AS 16.10.400.475), and fishermen would not have engaged in programs to assess themselves for hatcheries if it were not for limited entry. As it is, such assessment programs are operating in Prince William Sound and southern southeast Alaska, and others are in the formative stages in various parts of the state. The programs are not without controversy and dissent, but their mere existence or struggle for existence is significant.

Beyond the economic considerations mentioned earlier, it is difficult to indicate whether increased gross earnings are attributable in some part to limited entry, or simply to the increased price of fish. Perhaps the only argument that can be made here is a negative one. Especially given the Judge Boldt decision in the state of Washington, which made a large reallocation of salmon catches from non-Indian fishermen, entry into many of Alaska's salmon fisheries by residents and nonresidents would have increased without the current program so that both catch and earnings would be diluted and spread among more participants.

Hatcheries and rehabilitation programs, of course, may eventually contribute to the economic stability of the salmon fisheries. Improved incomes will allow fishermen the opportunity to get through lean years of the cycle more easily. And diversification will also create greater overall economic stability.

The best empirical measure of the generally improved economic condition of the salmon fisheries, whatever the causes, is the continually increasing price of entry permits. For example, consider the series of most frequently paid prices for 1976–78 in the following fisheries: southeast Alaska salmon purse seine $10 000, $15 000, $25 000; Bristol Bay salmon drift gillnet $2000, $10 000, $25 000. The increase in permit prices itself has a number of causes, but the fact that fishermen will pay the price indicates that they feel it is worth that amount to get in, and that they expect to recover the cost of entry.

CONSERVATION AND MANAGEMENT

Another of limited entry's stated goals is to promote "the conservation and the sustained yield management of Alaska's fishery resource . . ." (AS 16.43.010). It contributes toward that goal. Those who argue that limited entry is "an exclusively economic measure" might as well claim that the sun provides light but not heat.

All fisheries regulations allocate the resource, although they generally operate at the level of the individual participant and the resource, regulating fishing time, area, gear, etc. Such regulations not only allocate, they also affect the size of the harvest. Limited entry also works to allocate the resource and to affect the size of the harvest, but it operates at a different level, governing total fleet size. Since the magnitude of the harvest effort is in part a function of the fleet size, control of that element through limited entry provides another conservation tool.

Alaska's experience is that traditional management techniques lose their precision or effectiveness as the fleet increases, with the result that the risk of serious management error becomes greater. Also, as the number of vessels increases, gear restrictions force a greater degree of regulated inefficiency through banning the use of more effective techniques. There is also greater economic pressure on the individual fisherman to violate regulations. Limited entry has stopped the increase in the number of units of gear; it has stabilized one of the variables in fisheries management; and it can provide the potential for other management methods to be used with greater reliability, especially with the reduction of large fleets to an optimum size through buyback programs or other means.

To cite an example of conservation justifying the limitation of entry, consider the herring sac roe purse-seine fisheries that we have limited. These are "supplemental income" fisheries; given the other involvements of the participants, virtually no one really needs the money; everyone realizes he may well not make any; yet everyone fishes to see how he'll do. Salmon purse-seine vessels engage in the fishery before the salmon seasons, using special herring seines. The fishery may not take place in certain years if the herring do not show up in sufficient abundance, or if the roe is not ripe enough. When the fish are there, and the technicians decide the roe is ripe, 40 or more boats may engage in furious activity, sometimes working in coordination with airplane spotters, and play an incredible roulette game in which occasionally six winners can wrap up more than 600 tons or more of herring at nearly $1000/ton, and the remaining losers can often make nothing but "water hauls." In some cases the quota has not only been taken but seriously exceeded during the course of an opening measured in minutes, not hours. However, the herring come in at different densities and depths from year to year, and if the fleet in this example were reduced to six boats, in some years a few of them may get nothing, or all of them may get something and yet the quota not be taken.

The economic conditions that warrant limiting entry into a supplemental income fishery of this nature do not appear to exist. But for conservation and management reasons the number of participants must be limited. The administration of quotas has been aided and a harvest allowed consistent with the goal of sustained yield management where otherwise excess gear might have required total closures.

However, limited entry is, of course, also an economic measure; but then any resource allocation tool has economic consequences, as the fisherman can tell you when he does not get an opening, or the processor when he does not receive the right volume of product.

CONTROL OF EFFORT

One thing Alaska's limited entry program did not set out to do was control effort at the individual unit level.

The program is directed at the number of units of gear, but the efficiency with which those units of gear fish is controlled by the regulatory authority of the Alaska Board of Fisheries and the management authority of the Alaska Department of Fish and Game. This relationship requires a constant interplay between the Entry Commission and the two management entities in arriving at decisions of effort levels.

Nothing especially recommends or detracts from this method of doing things; it developed from the existing situation in Alaska when limited entry was established. In fisheries that may be limited in the future, such as shellfish, a tie-in of limited entry to particular effort levels must be considered.

BUYBACK

The Entry Commission has not yet instituted buyback programs in any of the fisheries under entry limitation. We are currently determining the need for such programs, which would be funded by an assessment of up to 7% of the gross attributable annually to each permit holder in a specific fishery. The Commission would operate on the market as another buyer of permits, and vessels and gear where necessary, to reduce the number of permits in a fishery to an optimum number. That number is identified as AS 16.43.290 as a reasonable balance of (1) the number of permits sufficient to maintain an economically healthy fishery that will result in a reasonable average rate of economic return to the fisherman participating in the fishery, considering time fished and necessary investments in vessels and gear; (2) the number of permits necessary to harvest the allowable commercial take during all years in an orderly, efficient manner, and consistent with sound fishery management techniques; and (3) the number of permits sufficient to avoid serious economic hardship to those currently engaged in the fishery, considering other economic opportunities reasonably available to them. If buyback programs are necessary, their results will be monitored to see what economic and conservation management effects might be specifically attributed to entry limitation at lower levels of participation. Such monitoring could define more accurately ways in which limited entry contributes to the goals of the program.

GOALS IN CONFLICT

As was suggested earlier in the discussion of the Chignik purse-seine fishery, over time some of these goals may prove to be in conflict with each other. If a fleet is decreased in size through buyback, professionalization and technological innovation may still prevent the Board of Fisheries from removing efficiency-reducing regulations because of management considerations (Crutchfield 1972). Rising fish prices may up the rate of return to the point where additional entry is warranted from an economic standpoint, but forestalled or reduced in scope in the name of conservation. Some conflicts such as these are solvable; others may not be.

BENEFITS OF ARREST

The possibility of such conflicts, however, does not mean that limited entry should be abandoned, because in addition to whatever positive benefits limited entry may confer, there is another benefit that must be mentioned, although it can never be demonstrated. Limited entry prevents the problems caused by increased participation from becoming worse.

Problems

In implementing limited entry programs, some problems seem to be inevitable, while others can be avoided, or at least planned for so that they can be handled effectively. Alaska, fortunately, had the opportunity to review British Columbia's limited entry program and to benefit from a knowledge of problems encountered there. In some cases, problems encountered by Alaska can be inferred from observations made elsewhere in this paper. (In other cases, however, the observations describe the results of foresight and/or good luck, by which problems were avoided.) As for various problems, here are a dozen that I hope will be of general interest.

NECESSARY INFORMATION

1) A broad, historical base of information on fisheries (including the fishermen in them) is an ideal starting place for considerations of limited entry. You cannot design and implement a good system without good information. If you lack certain information you must set up and implement the means to get it, and, recognizing the goals and constraints of your situation, you must distinguish between necessary information and that which would be nice to have. The kinds of information available can set limits on the types of limited entry systems that can be employed and the criteria that can be used to allocate permits.

Additionally, the time required to gather and analyze certain information sometimes suggests various problems, such as (a) whether the material will be outdated by the time it is ready; (b) how to update baseline studies; (c) wether a situation may deteriorate to a point that may warrant a decision without the information in question; and (d) what information to get and what to forego.

COMPLEXITY

2) Alaska's system for allocating entry permits is complex. It was made that way to avoid the social and economic dislocation that would have occurred if permits had been awarded on some simple basis such as level of catch. In terms of allocating between residents and nonresidents, the system has retained the prelimit

balance to within plus or minus approximately 3%. To the extent that we have studied it, the system has also distributed permits to individual communities almost exactly in proportion to the number and types of units of gear fished before limited entry.

The problem we faced because of complexity was explaining the application process to the fishermen with varied cultural and language backgrounds. This required that we provide application completion assistance, working with fishermen even after applications were received to develop evidence, and holding hearings and adjudications on facts and issues that required interpretation to determine their conformity with Alaska's law and the Entry Commission's regulations. We believe the problem of complexity has been handled satisfactorily. Alaska Legal Services Corporation believes we did not provide adequate application assistance and is suing us. Adequate assistance must be provided to fishermen throughout any application process.

"PART-TIMERS" VS. "FULL-TIMERS"

3) The problem of how to treat "part-timers" relative to "full-timers" was a job that appeared deceptively easy to some. In their view, the Entry Commission was to keep the full-timers and get rid of the part-timers, who in the Alaskan sense of the word were fishermen with nonfishing jobs, such as teachers, doctors, and lawyers. However, the task did not turn out to be that simple. The easy, comfortable distinction between part-timer and full-timer disappeared in a sea of facts whose configuration varied from fishery to fishery. Some fisheries had few part-timers, some had virtually all part-timers, and in others the nature of the nonfishing employment varied considerably.

The part-timer–full-timer problem was handled in each fishery by an application process that used a variety of standards to put the problem into a broader context tailored specifically for each fishery. The process entailed a point system under which different considerations were given different point weights, with the thresholds for certain considerations being adjusted to the character of each fishery. For some categories, points were weighted in favor of years closest to the qualification cut-off date since remoteness in time indicated a lesser involvement in the fishery. In addition, allowance was made for applicants with unavoidable circumstances.

The results were not universally satisfying to all "full-time" fishermen, since some of those traditionally identified as "part-timers" received permits.

LEGAL CONSTRAINTS

4) Obtaining public understanding and acceptance of the legal constraints that exist in designing or implementing entry systems is a definite problem. In one form or another, the problem of understanding and accepting legal constraints also exists for Entry Commissioners, fishery managers, economists, legislators and government administrators, staff personnel — in fact, the person is rare who is untouched by it. Even lawyers disagree about what the legal constraints are.

To build without a sound legal foundation is to build on sand. The Canadians, with a different legal system, created limited entry at the federal level with a broad stroke almost as simple as one from the Old Testament, although instead of "Fiat lux," the pronouncement was "Fiat limited entry." There have been no lawsuits over limited entry in Canada. In the United States sound advice in establishing limited entry systems is "always work with a lawyer, and have a good one."

ALLOCATION CRITERIA LITIGATION

5) The legislature and the Entry Commission used the criterion of being a licensed gear operator to give greater weight to certain applicants. Several parties are suing the Entry Commission on various ways we used a person's status as an operator of gear to give more credit toward receipt of an entry permit. It is recognized that not all areas have similar licensing systems. The lesson to be drawn is that one must be scrupulously careful about the allocation criteria employed in deciding who will receive entry permits.

THE LITIGATION WORKLOAD

6) Generally speaking, litigation can be a problem in terms of staff time and costs involved; given the implementation of a new program with significant social and economic consequences, litigation should be welcomed as a legitimizing test of the program, but its effects should be anticipated and planned for. As of May 1978, the Entry Commission had 39 suits against it, with several more anticipated.

ENTRY PERMIT PRICES

7) The rising price of entry permits is argued by some to be a problem with limited entry. In terms of most frequently paid prices during the first part of 1978, compared with 1977, a sampling of salmon fisheries indicates the following: southeastern purse-seine $25 000–$15 000; Kodiak set net $5000–$4500. Some permits trade for far more, some for less.

Concerning these prices a number of things should be kept in mind: Most significant, perhaps, is that entry permits are still a new commodity whose certain continued existence was established only with the failure to repeal limited entry in the November 1976 election. Consequently, many fishermen are still learning what a permit is worth, and some bitter experiences of paying too much and suffering a loss are likely to temper current upward price trends. While some fishermen may not have understood the nature of this type of investment at the beginning, they are catching on.

In addition, earnings in many fisheries in recent years have been good enough that a permit can be paid off in a year or two, with a profit remaining. Good runs and good predictions in many areas have caused prices to rise. Permit buyers generally expect to be highliners, not mediocre fishermen. And, to wrap up the list, during the first 3 mo of 1978 a total of 193 people in 19 of the 25 limited salmon fisheries purchased permits compared with 114 people during the same period in 1977, indicating that higher prices are not interfering with the *rate* at which new entrants are aquiring permits from current holders.

COMMUNITY DISRUPTION

8) There have been problems alleged concerning a significant number of entry permits being sold out of predominantly native villages where fishing is a key factor in the economy. An Entry Commission investigation of permits in the villages in southeast Alaska showed initial permit allocations corresponding quite closely to fishing patterns in the years immediately preceding limited entry. It also showed that, in all villages but one, while there were some minor fluctuations in numbers of permits, the overall patterns were stable. In the single community that was the exception, clear causes were indentifiable, including the closure of two canneries that were the primary markets for the local fleet, and a traditional sense of territoriality that discouraged fishermen from traveling too far from home. Overall, however, we have not yet found that limited entry has led to significant disruptions of community life.

PROGRAM MONITORING

9) The general absence of established and ongoing social and economic monitoring systems in fisheries is a problem whose scope goes well beyond limited entry. As for our program, the tasks and timing of implementation have not yet allowed us to develop the degree of monitoring we believe is necessary. Monitoring provides deliberate feedback systems to indicate where adjustments to the program or actions to modify program effects may be appropriate.

EFFECTS ON NONLIMITED FISHERIES

10) To some extent the effect of limiting entry in certain fisheries but not others is like squeezing a long balloon: when a constriction is applied in certain areas expansion occurs in others. The difference is that the balloon is under increasing pressure from additional entrants to the fisheries. The areas of expansion are governed by availability of the resource, the cost of entry, the price of fish, and the availability of markets.

The anticipation of limited entry has produced effects of its own. Alaska's shellfish fisheries are typical of what is happening generally: an effort to achieve what is believed to be an enhanced position should limited entry be imposed. Each year fishermen are purchasing interim-use permits for a wider variety of fisheries not under entry limitation; some are bringing in additional boats; some are engaging more or less seriously in additional fisheries; others are making token landings; others are just hoping that mere possession of a permit will provide them with some kind of "rights."

These effects may be viewed as problems or phenomena; whether the phenomena become problems depends in part on conditions in the fishery and in part on the consequences. On the one hand, it can be said that limited entry is encouraging professionalization and diversification in fisheries that can stand additional effort. On the other hand, it can be said that the prospect of limited entry is causing problems in already overcrowded fisheries, and in cases where fishermen are extending themselves financially and otherwise taking questionable risks.

STAYING AHEAD OF THE GAME

11) The fond dream of every limited entry administrator involved in Alaska's program has been that in the *next* fishery to come under entry limitation we would not have to cut anyone out. The idea is simple: if you can put the lid on in time, everyone who has been in can stay in. So far the idea seems to be on the horizon, and like the horizon it recedes continually as you try to approach it.

A variety of problems discussed elsewhere are also involved in this one. Three interrelated matters call for specific note here: turnover, timely recognition, and information lag.

Over time, fishermen drop in and out of any fishery, sometimes repeatedly. This turnover, which may run 30% or more annually, should be tracked and accounted for if a decision is anticipated that would, for example, sweep in everyone who fished in the last 5 yr. Waiting until the current year's number of participants hits the saturation level ignores turnover and obviates the possibility of grandfathering in everyone.

Recognition of the saturation level generally does not take place until that level is reached. In any earlier year, there was no crisis and consequently no generally recognized need to limit entry. Timely recognition of the need to start limiting entry — on the part of a variety of affected parties, not just a program manager — is an essential prerequisite to broad grandfathering.

Finally, information lag hampers everyone's knowledge of trends and changes. Timely information is necessary to develop and implement limited entry systems before participation levels become excessive.

Without the necessary means to stay ahead of the game, it appears inevitable some form of allocating among past participants will be a part of future limited entry systems.

THE ROMANCE OF CONTINUITY

12) One of the most pervasive problems in regard to limited entry is the romance of continuity in a world of change. It can take many forms. Those in a fishery can wish that it could continue without entry limitation as it has in the past, even though conditions in the fishery have changed. Those dealing with various models of a fishery can find themselves drawn to or using static models (which may be the only thing available) while dynamic models are more appropriate. Those considering social structures and cultural conditions can feel that the past should carry over automatically into a different and changing future. This is not to suggest that the past should be jettisoned in favor of some newly conceived future. Rather, the romance of continuity is a problem to the extent that it distorts our perceptions of changes that have occurred and are going to occur in fisheries.

Future Challenges

From the perspective of those first considering whether to employ limited entry in a fishery, nearly everything is a future challenge. For the Entry Commission in Alaska many of the matters discussed earlier become challenges once again whenever we move to implement limited entry in a new fishery. However, commission consideration of the possibility of limiting entry into the shellfish, longline, and trawl fisheries off Alaska has brought some additional matters into focus which will be discussed here. They are, briefly, identifying a need for limited entry, determining whether it is feasible, finding the appropriate form, obtaining input from interested and potentially affected parties, identifying steps that flow from a joint state–federal involvement, and recognizing the conditions required before implementation is possible.

DO WE NEED IT?

In each case to date the Entry Commission has responded to a generally recognized need for limited entry. No such need is currently recognized by many in Alaska's shellfish fisheries, which are considered to include king crab, tanner crab, dungeness crab, and shrimp. The question of need is further complicated by the potential for involvement of shellfish vessels in the developing longline and trawl fisheries. Naturally, limited entry should not be implemented unless needed, but it is so revolutionary in fisheries that a clear, generally understood answer to the question of what constitutes need must emerge before further progress can be made toward implementation.

Regional differences, as well as differences between fisheries in a given region, govern the relevance of various considerations bearing on the need for limited entry. What is highly important in one area may be safely neglected in another. The list of considerations that follows is not intended to be exhaustive.

We have identified a host of factors to be considered in determining whether entry limitation is necessary. No one factor is inherently significant enough to answer the question by itself, nor on the other hand must all factors point to a need for limited entry to conclude reasonably that entry limitation is warranted. Rather, the factors to be considered are indicators of the degree of various problems, if any, that may be appropriately addressed by a form of limited access system. Some of the more relevant factors are

— extent of domestic utilization of the fishery resource;

— interrelationships with other fisheries: extent of nontarget species catch and mortality; degree of dependence upon other fisheries;

— any trends in the precision or effectiveness of conventional management techniques that indicate a serious risk of major overharvest due to management error;

— trends in the number, efficiency, and capacity of the vessels in the fishery;

— degree of excess, utilized, or underutilized capacity in the fleet;

— adequacy of economic returns to fishery participants;

— extent to which regulatory measures necessary for reasonable biological management of the fishery impose artificial inefficiencies on the fleet;

— onshore effects from any of the above factors, including quality of standard of living, degree of unemployment, dependence on transfer payments, and labor force retention problems.

Fisheries should be monitored and data collected so that conditions such as those described above can be identified and measured. The following information would be useful:

a) investment in vessels and gear with detailed information on the number, type, and efficiency of the different units of gear;

b) the relationships between the various inputs into the harvesting of fish and the levels of output;

c) the costs of fishing at different levels of output;

d) the size, species composition, and spatial distribution of catch;

e) the marketing channels and demand and price structures;

f) the patterns of fleet diversification into other species of fish, and into different areas;

g) social and cultural data about the fishermen as members of the community of fishermen exploiting a fishery, and as members of shore-based communities;

h) stock assessments.

With such a monitoring program, if managerial and/or economic indicators signal the need for limited entry, much useful information will be available to allow timely design and implementation of the best program.

Means should also be established to determine the optimum effort levels for fisheries to provide reference points for evaluating changes. Two major considerations here are (1) a level that allows effective resource management, and (2) a level that allows a reasonable average rate of return. These concepts, and perhaps others, would have to be elaborated and specified for each fishery. Other considerations bearing on optimum effort levels may suggest themselves as the concept of optimum yield is developed.

FEASIBILITY WITH MULTISPECIES, AREA, GEAR

Because of stock and price fluctuations, shellfish fishermen assert that they must have a certain mobility between areas and flexibility regarding target species to remain economically viable. I think they are right and the Entry Commission believes that a multispecies, multiarea approach to limited entry must be considered. Consideration must also be given to allowing multiple gear types. With stocks and effort levels varying from area to area, and even within an area, the matter is complicated.

Crucial to these considerations is whether a limited entry system can be established that does not stifle diversification. The king crab fishery in the Bering Sea, for example, is undoubtedly overcapitalized, and to some people that alone might warrant entry limitation. However, the tanner crab fishery is far from being harvested exclusively by the domestic fleet, although many of the same vessels participate in both fisheries, and domestic trawl fisheries are just beginning to develop.

Limited entry for a fisheries complex entailing not only varying participants, stocks, and areas, but also changing degrees of domestic involvement may not be feasible. Certainly a large task is ahead to see what kind of bridge might be built between theory and practicality.

FINDING AN APPROPRIATE FORM

The feasibility of limited entry is connected with the specific form it will take, and the question of form is intertwined with questions of precisely what constitutes the need and what the goals and expected consequences are. Thus, in considering limited entry for Alaska's shellfish, longline, and trawl fisheries, we find ourselves examining alternative forms to meet different complexes of needs and produce different patterns of results.

One reasons that Alaska's current limited entry law works well overall for the salmon and herring fisheries to which it has been applied is that the permit issuance criteria (allocation standards) allow a high degree of flexibility. Flexibility in specific application to cover a variety of situations must be preserved in the design of future limited entry systems as well.

The goals for limited entry in the salmon fisheries were also fairly clearly in mind. There is a tendency to dodge the work of specifically formulating goals, since discussion can get hopelessly mired and seems to prevent everyone from getting on with "the real job" of creating something. But goals will help determine the form a limited entry system may take, they provide direction for the subsequent program, and they provide reference points for measuring progress.

The various forms of limited entry (licensing vessels, licensing individuals, quota shares, taxes, etc.) have been discussed elsewhere in the literature on limited entry. However, identifying the form or forms appropriate to a given fishery and developing the details necessary for a sensitive application is a large task. To stimulate discussion of goals and particular forms of limited entry we have advanced a number of suggestions to those in the fisheries under consideration.

ARE YOU OUT THERE?

The job of examining and finally deciding upon goals and forms of limited entry is not something that should be undertaken by mutually consenting bureaucrats in the privacy of their offices. Comment, input, and insight are needed from all interested and potentially affected parties. The Entry Commission is seeking broad professional, industry, and public involvement in its considerations of limited entry for the shellfish, longline, and trawl fisheries of Alaska, but with three exceptions the response after more than half a year has been nil.

Perhaps the lack of response stems from a lack of perceived immediacy or urgency. Whatever the cause, it is handicapping effective planning and evaluation, and the Entry Commission is striving to change the situation.

There are several reasons for seeking broad involvement:

1) It seems to be the best way to develop a comprehensive sense of the likely consequences of various limited entry systems. This is especially true for fisheries such as shellfish or trawl with short histories.

2) The parties likely to be affected must be consulted and their views considered; they are the ones limited entry might happen to.

3) Insights and innovations can come from many quarters, and no one should turn down the chance at a good idea.

4) Ideas are like living things — some abort, some grow, some metamorphose; time and conditions should be provided to see what happens to them and to reap the best harvest.

Through research and reflection, expert advice, input from the fishing community, and mutual education, it may be that some controlled version of quota shares or taxes takes the ascendancy, leaving variations on permits to individuals or vessels behind, or incorporating aspects of those ideas. It is hard to tell what combination of ideas may be necessary to arrive at the "best" solution, but it is premature to guess the future at this time and better to let what can be broadly construed as a democratic process work.

STATE–FEDERAL INVOLVEMENTS

Once we posit a multispecies, area, gear approach for the fisheries under consideration, it becomes necessary to develop a state limited entry system that is compatible with the Fishery Conservation and Management Act of 1976 (FCMA) and is acceptable to the North Pacific Fishery Management Council and the Secretary of Commerce.

At the legal level, this means that any state limited entry law must be in fairly explicity conformity with the FCMA, especially in connection with the Federal law's National Standards, and its limited entry provisions. Since no such limited entry programs have yet been elaborated, the consideration of limited entry for the shellfish fisheries and others under joint jurisdiction will be developmental work of benefit to the federal government as well as the state.

Such joint efforts require the recognition of all that is entailed in getting state laws changed or enacted, and, should some limited entry system be entertained that is not currently permitted by the FCMA, the need for congressional action.

At the policy and program level, this also means that the North Pacific Fishery Management Council will have to make coordinated changes in a number of management plans so that an integrated limited entry system may be implemented, and it means that designation or creation of a vehicle for implementation.

Summary and Conclusion

The complex and changing nature of fisheries makes it difficult to isolate effects specifically attributable to limited entry and measure its contribution toward reaching goals. Limited entry is, of course, only one causal factor among many, ranging from national and international economics to foreign treaties and extended jurisdiction, social conditions, changing stock conditions, the state of the art in management and research, hatcheries and rehabilitation programs, and whatever else happens to be dear to any particular individual from his special perspective on the subject of fisheries. Limited entry should be viewed in this broader context, but because it is new in fisheries and because it brings about significant changes in the range and nature of social and economic behavior, it tends to stand out in the crowd.

SUMMARY

To summarize some of the high points of Alaska's experience with limited entry: You must identify a need and attempt to define clear goals. You must have information on the resource, the users of the resource, and the likely consequences of various trends in a fishery. Public participation in the development of this information, and public education concerning the facts and issues involved, will facilitate the implementation of limited entry in a timely manner. Although such public involvement is time consuming, it is important if not essential to the success of limited entry programs. An articulated need, clear goals, solid information, clear thought, and public involvement become even more important cornerstones in states where a sizeable nonfishing constituency may be involved in various stages of the decision-making process.

The actual "how to" of implementing limited entry perhaps cannot be set down in many general terms that will be useful. Economic, social, political situations can vary, and the nature of the need for limited entry can vary, and the specific form of limited entry should vary to fit the situation and need. Consequently, implementation becomes a function of these elements. However, I will hazard a brief checklist:

— There must be a high level of concern for people at all stages of process. Limited entry programs affect people and how they can live.

— A limited entry system must be fair and must be perceived as fair. Those people potentially affected should participate in its development. Those actually affected should understand what is happening to them.

— Limited entry programs must be tailored to specific fisheries to minimize or avoid adverse social or economic effects.

— Competent experts should be engaged as necessary at all stages from conception through implementation to help assure a high standard of quality in what is being done.

— The entity implementing a limited entry program should have sufficient size, responsibility, authority to carry out its task.

— Excellence should be sought, but perfection should not be expected in implementation. This is only to acknowledge what everyone knows: the courts, for example, occasionally convict an innocent man or free a guilty one, but overall the system works well. The expectations for any limited entry system should not be higher.

CONCLUSION

Based on Alaska's experience, the general political formula for establishing a limited entry system seems to be that it is not possible to get action before a crisis or a disaster. Webster's New World Dictionary defines "crisis" as "A time of great danger or trouble, whose outcome decides whether possible bad consequences will follow." And "disaster" is defined as "Any happening that causes great harm or damage; serious or sudden misfortune; calamity." Absent a spur that sharp, it is not likely that there will be successful movement toward the establishment and implementation of limited entry systems.

This is an offensive formula, which should cause a number of people to rebel in the hope that preventive or timely action is possible to forestall crisis or disaster.

The opportunity for success in such action is predicated in part by the clear identification of the facts that indicate a need for limited entry, and a general public understanding not only for those factors but of the consequences of inaction.

But another possible gremlin in the works must also be identified. In Alaska we have found that in discussing the possibility of applying some form of limited entry to the shellfish fisheries or the salmon hand troll fishery, the general public expects that traditional management methods must be tried first and proven unsuccessful in achieving management and socioeconomic goals. That is, if traditional management techniques can no longer protect the resource, or if they can do so only at the cost of serious social and economic dislocation, then it is appropriate to turn to limited entry.

If this requirement of "traditional methods first" must be met in all areas before significant action can be taken toward limited entry, then it seems that there is a kind of curious reasoning that inevitably binds one to a crisis or disaster. It runs: limited entry is not needed unless traditional methods prove unsuccessful; the crisis or disaster brought about by such lack of success is the indicator of the need for limited entry.

At worst, it can be argued that planning now for the coming disaster should be encouraged so that if, or when, it occurs a timely response is possible, minimizing ill effects. Otherwise, an injurious situation, although finally recognized, may worsen over a longer period of time before corrective action can be taken.

At best, it can be argued that identifying need criteria now, gathering information, and engaging the potentially affected public may allow more appropriate action to be taken on the basis of trends that have not yet reached a disasterous fruition.

Given the generally prevalent social, political, and economic attitudes, the establishment and implementation of limited entry systems currently appears likely to come about only after there is a crisis or disaster in a fishery. It will take extensive preparation and general education beforehand to create a climate in which timely action will be possible on the basis of reliable, understood trends and relationships. In many cases, the next 10 years or less may tell whether it is possible to have action before crisis or disaster in our fisheries.

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Alaska's Limited Entry Program: Another View[1]

GEORGE W. ROGERS

University of Alaska, Institute of Social and Economic Research, Juneau, AK 99801, USA

ROGERS, G. W. 1979. Alaska's limited entry program: another view. J. Fish. Res. Board Can. 36: 783–788.

Viewed in an historical perspective, the 1973 Alaska limited entry law evolved from fisheries policies motivated by distributive (Alaska first) and social (maintenance of rural fishing communities) criteria more than the traditional economic criteria of efficiency. Fisheries economics research has been primarily concerned with such matters as dissipation of economic rent through excessive units of harvesting. There is a need to expand this research into employment, labor mobility, and the evaluation of opportunity costs as well as economic efficiency.

Key words: fisheries management, limited entry; Alaska; economics; political science and government; public policy

ROGERS, G. W. 1979. Alaska's limited entry program: another view. J. Fish. Res. Board Can. 36: 783–788.

Quand on examine dans une perspective historique la loi de 1973 sur la limitation de l'entrée dans les pêches d'Alaska, on constate qu'elle découle davantage de politiques motivées par des critères de distribution (Alaska d'abord) et sociaux (maintien des collectivités de pêche rurales) que de critères économiques traditionnels d'efficacité. La recherche en économie des pêches a porté avant tout sur des questions telles que la dispersion de la rentabilité économique par suite du nombre excessif d'unités de récolte. Il faudra élargir cette recherche pour inclure l'emploi, la mobilité de la main-d'oeuvre et l'évaluation des coûts d'entreprise et de l'efficacité économique.

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ADASIAK (1979) has reviewed the experience with the 1973 Alaska limited entry program, examined the immediate environment from which it arose, and identified major problems and probable future developments. The purpose of this paper is to review in a longer historical perspective the process that culminated in the 1973 program and to examine the specific objectives in terms of which this program and its predecessors attempted to rationalize fisheries. It will not extend into the forward looking perspective of Adasiak's view, because it is intended to use the past experience as a means of considering the role of the economist in relation to politically determined objectives for fisheries.

Before the Fall — The Aboriginal Limited Entry System

The concept of the Alaska fisheries as an open access resource was an innovation of the early commercial fisheries era of Alaska's history, and in a sense the current system of limited entry might be viewed as an attempt to achieve something comparable to the more rational approach embodied in the displaced aboriginal resource use-rights system. The Tlingits in Southeast Alaska, for example, had a well-developed and defined system of "property" in the form of use-rights to specified salmon streams and other natural resource areas. These rights were generally held by the local member of a clan or house group who could exclude others from the use of the subject resource. Individual behavior within these groups was strictly regulated by custom and hierarchy.

The continuing force of these rights was reported in 1907 by a cannery operator who imported a fishing crew from Angoon to fish a stream after the local Sitka crew refused to fish further for conservation reasons. "The Sitkas claimed the exclusive rights to fish in that locality and resented the coming of the Killisnoo crew. The latter, knowing of the old Indian right claim, refused not only to fish there, but demanded that they at once be taken from the cannery, declining to remain the night through. They claimed that had they stayed there the Sitka Indians would have returned after dark and killed them, and they also asserted that the Sitka Indians would have had a perfect right to do so." (Rogers 1960, p. 272–279; quoted material from p. 279.)

The aboriginal system of local ownership of and control of access to salmon resources served subsistence or home consumption fisheries. An example of how this system might have been adapted to the commercial

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fisheries inaugurated in the late 19th century, however, exists in the case history of Metlakatla. This community was established in 1887 when about 800 Tsimshian Indians under the leadership of William Duncan migrated from British Columbia because of a disagreement with the London Missionary Society and disputes with government agents at Victoria. This was in effect the transplanting of an already functioning and successful utopian society which combined a rigid Christian idealism with the full utilization of 19th century technological advances. Like all utopias it was not without its elements of tyranny, but whatever might be said about social or political repression it was an unqualified economic success.

Duncan persuaded a distant and disinterested U.S. Congress to establish the Annette Island Reserve in 1891 granting the settlement not only the land, but exclusive fishing rights in the waters surrounding the island. The island's salmon streams were efficiently fished by carefully managed fish traps (still in operation despite the State's constitutional outlawing of the device) and a fishing fleet participated in other fisheries. Unlike other commercial developments in Alaska, however, all the income and profits of harvesting, processing, and marketing went to the community and for many years Metlakatla was one of the wealthiest towns in Alaska. This case demonstrated that if limited entry was carried far enough and was accompanied by an appropriate system of ownership it could eliminate conflict between objectives of efficiency and maximized local employment and income (Rogers 1960, p. 209–211).

Genesis of Alaska Limited Entry — Open Access and Nonresident Control

The aboriginal system was overrun by the canned salmon stampede between 1878 to the turn of the century and replaced by an open access system. Between 1918 and 1921 the resource crashed. In their 1919 report on the Alaska fisheries, Gilbert and O'Malley identified the problem of conserving the salmon resource with open access and the unreality of expecting anyone to voluntarily forgo a profit. If fishing grounds or rights could be leased or assigned, the value of the inherent property rights would be a function of the continued yield which would be conditioned by the conservation of the resource and would assure the processors' cooperation in such efforts. The fisheries should be left in private hands, according to the report's recommendations, with the canneries exercising quasi-public functions by operating under licenses that restrict their limits and scale and specify the amount and type of gear to be utilized in harvesting (Cooley 1963, p. 107–108).

The essence of these recommendations was embodied in executive orders issued by President Harding creating the Alaska Peninsula Fishery Reserve (February 1922) and the Southwestern Fishery Reservation (March 1922). Before it had a chance for a fair trial, however, the reservation concept was abolished by the passage of the White Fisheries Act of 1924. This legislation provided, among other things, that "no exclusive or several right of fishery shall be granted therein, nor shall any citizen of the United States be denied the right to take, prepare, cure, or preserve fish or shellfish in any area of the waters of Alaska where fishing is permitted." The dismantling of this first attempt at fisheries rationalization resulted from a number of forces: the turn of the century reaction against and suspicion of big business, the emerging labor movement, and the clouds of scandal gathering over the Harding administration's public land and resource management and disposal practices. The Alaskan opposition was not to limited entry as a policy, but the parcelling out of a public resource to private absentee interests which in effect required a fisherman to become a tenant of a cannery in order to engage in his vocation (Cooley 1963, p. 110–127; Crutchfield and Pontecorvo 1969, p. 72, p. 95–98).

The 1924 Act's prohibition of the granting of exclusive rights and privileges in any fishery was seen by Alaskans as aimed at nonresident control and was subsequently translated almost verbatim as a section of the natural resources article of the Alaska Constitution of 1956. But there was a further potent vehicle of nonresident control that had to be dealt with, the fish traps. During most of Alaska's history as a territory, from 75 to 90% of the traps were owned by the canneries and accounted for over 40% of the total salmon catch. The control over production and the price paid to mobile gear operators this gave the canners was considered by Alaskans as a device limiting both resident fishermen entry and income.

Traps become a natural focus for nonresident opposition, which was not lost on the framers of the 1956 constitution who, as a means of assuring acceptance of this document, attached an ordinance abolishing fish traps. With the passage of the Statehood Act Alaska was entitled to two U.S. Senators and one Congressman, and the Republican Secretary of the Interior, with these political prizes in view, wasted no time in turning control of the fisheries over to the new state and outlawing traps (Rogers 1960, p. 3–16).

Limited Entry for Nonresidents, the 1962 and 1968 Acts

Although statehood greatly reduced nonresident influence in fisheries management and control over entry, the next step was reduction of nonresident participation. Continued low resource yields and increasing participation led to the inescapable conclusion that some form of gear restriction was needed. The obvious group of fishermen to be reduced was nonresidents, and the Legislature in 1962 and 1968 made two attempts at this form of limited entry. The legislative language of the 1962 act provided that

> "Whenever the Board [of Fish and Game] determines that the year run of salmon in any one registration area will be substantially less than the optimum run, and that under anticipated fishing conditions Alaska residents licensed by the area or district will not catch sufficient fish to sustain them for the year, the Board may, with the consent of the local advisory board or boards, promulgate regulations temporarily closing the area of district to fishing by all non-residents of Alaska." (*Alaska Session Laws*, 1962, Chapter 62)

Before any regulations could be issued under the act, however, the Federal District Court declared the act unconstitutional on grounds of violation of the privileges and immunities clauses of the federal constitution as well as portions of the Alaska Constitution. The court further held that the theory of ownership of the fisheries by the State of Alaska, upon which the legislation was built, had been put to rest by previous court cases and, finally, the law constituted a burden on interstate commerce (Wunnicke 1972, p. 263–264).

Spurred by the Bristol Bay fishing disaster the 1968 state legislature passed a statewide salmon net gear limited entry program (*Session Laws of Alaska* 1968, Chapter 186). The Board was authorized to issue a gear license to an applicant who either had previously held a salmon net gear license for a registration area or had held a commercial fishing license for any 3 yr and had actively engaged in fishing that area. In effect, the second alternative set up an apprenticeship program whereby crewmen could qualify for a gear license after 3 yr. This had a positive ring and gave the appearance of hope for new entrants, but there was a catch. The sponsors of the bill reported that the law was "designed to protect the interests of Alaska fishermen. The sponsors of the bill in both the House and the Senate included the three-year apprenticeship provision to discourage part-time and vacationing fishermen from other areas of Alaska and the "lower 48" states. These fishermen could not readily have served the three years and would probably have been excluded." (Morehouse and Hession 1972, p. 312)

This underlying purpose was obvious to the federal court, however, and in February 1969 it was determined that the law and regulations violated clauses of both the Alaska and Federal constitutions.

> ". . . If any outsider wishes to fish for salmon in a given year, and in three years to qualify for his own gear license, his chances are wholly dependent upon obtaining employment under a member of that closed class of fishermen, who, in the specified past years, possessed the right to fish in the area . . . Under the scheme, entry into the salmon fishing industry is controlled not by the state, but by local fishermen in each area who are eligible for gear licenses and can choose among the commercial fishermen, if any, that they may wish to hire. The power to permit competition cannot be vested in *private* interests whose own benefit would ordinarily not be served by assisting potential competition to qualify." (Morehouse and Hession 1972, p. 311)

Objectives of the 1973 Limited Entry Program

In January 1972 the Governor of Alaska received an appropriation to fund a limited entry study group; Article VIII, Section 15 of the Alaska Constitution (the principal rock upon which the earlier program foundered) was appropriately amended by the electorate on August 22, 1972; the Governor's bill was introduced into the legislature in January 1973, followed by the detailed report of the Study Group in February 1973; and in April 1973 a bill creating the limited entry program was passed by the legislature and signed into law by the governor (Adasiak 1977, p. 190–197). There is no need to review this process yet again, but some attention should be paid to the emergence of statements of purpose.

During preparation of the 1973 limited entry legislation, a number of statements emerged that defined the basic objectives of that program. The traditional conservation and sustained yield objectives were joined by a range of social and economic objectives. Economic efficiency objectives were absent, however, for in the context of economic distress and social disruption in most of Alaska's fishing communities, talk of the reduction of "waste" of labor and capital in the harvest would have been met with contempt and anger. As Scott observed from a much broader review of economic rationalization of fisheries, this is not an unexpected reaction.

> "Economists' surveys of fishery regulation make much of the power of government action to remedy the wastes of common property and similar market failure. But I do not believe that an increase in efficiency in resource allocation very often enters into politician's motivation for intervening in the fishery, or in any other sector. . . . [T]hey are understandably unenthusiastic about measures that may displace people from jobs, close down plants, or empty ports." (Scott 1979)

Despite court rulings the old struggle of resident vs. nonresident interests remained basic to consideration of a new limited entry program. Typical of the fishermen's renewed plea to restrict the number of nonresidents was that addressed to the Governor's study group by the President of the Bristol Bay Native Corporation which concluded

> "As this disastrous fishing season draws to a dreary close, many of our local resident fishermen will be standing by, watching outsiders earn-

> ing a living at their doorstep. . . . Is there anything we can do to provide better protection for the resident fishermen of Bristol Bay, who must fish their waters along with so many others who leave right after the fishing season? Cannot we make more jobs available to local people so that they can earn money close to where they live?" (Rogers and Listowski 1972, p. 79)

Those who were charged with the task of regulating and managing Alaska's fisheries had a longer list of questions, the answers to which would define a list of social and economic objectives:

> "What effect will alternative limited entry proposals have on the resident–nonresident aspects of Alaska's fisheries? What effect will limited entry have on the present and future livelihood of members of fishing villages totally dependent on fishing — especially that of Natives who characteristically do not have educational, social, or psychological mobility enabling them to move to urban centres for work in other industries? Who would be prevented from fishing if a history of consecutive fishing over 3 years, 5 years, x years, was required to qualify for a license? Who would likely remain in the fishery if license fees were increased 5-fold, 10-fold . . .? How can a system of limited entry be instituted such that it does not create a rich class of elite fishing barons at the exclusion of others entitled to a decent living? What is the impact and effect of gear limitation on sport and subsistence fisheries?" (Alaska Department of Fish and Game 1972, p. 3–4)

The language of the August 1972 constitutional amendment was more selective and specific. The original Section 15 stated simply and in full "No exclusive right or special privilege of fishery shall be created or authorized in the natural waters of the State." The amendment went on to add the following: "This section does not restrict the power of the state to limit entry into any fishery for purposes of resource conservation, to prevent economic distress among fishermen and those dependent upon them for a livelihood and to promote the efficient development of aquaculture." Conservation, economic welfare, and aquaculture were the constitutionally allowed purposes of limited entry. Reference to resident and nonresident differences was avoided, but also avoided was reference to economic efficiency.

The central theme of the February 1973 report of the Governor's study group was more narrowly the economic welfare of fishermen and fishing communities and the bulk of the statistics presented were on employment trends and characteristics of license holders and the relation of fisheries to all other employment. The Foreword summed up this focus:

> "This study is the first large-scale effort by the State of Alaska to gather information on. . . . the historically by-passed human resource aspect of the salmon fishery — the commercial fisherman. What has been accomplished in this study is just the beginning of the analysis that will be required to put a limited entry program to work that is sensitive to the differences among commercial fishermen and the fisheries throughout the state." (Governor's Study Group 1973, Foreword)

As a contribution toward the preparation of Alaska's limited entry program, the National Marine Fisheries Service entered into a contract with the University of Alaska that recognized potentially adverse impacts of limited entry and the need "to develop means for including the social and economic costs of labor displacement as well as the economic gains of efficiency resulting from changes in the harvesting labor force of a fishery." (Rogers and Listowski 1972, p. 1) The statistical series and analysis developed in this 1972 study were subsequently incorporated in the 1973 report of the Governor's Study Group and provided the basis for the design of provisions reflecting economic welfare of fishermen.

The statement of purpose in the 1973 Act is limited only to promotion of "the conservation and the sustained yield management of Alaska's fishery resource and the economic health and stability of commercial fishing in Alaska." The findings go a bit further and conclude that present levels of participation "have impaired or threaten to impair the economic welfare of the fisheries of the state, the overall efficiency of the harvest, and the sustained yield management of the fishery resource." Beyond this mention of "overall efficiency" few additional words are devoted elsewhere to the subject.

The "optimum" number of entry permits are to be established by a balancing of three standards: the number of entry permits sufficient to (1) maintain an economically healthy fishery (defined in terms of a "reasonable average rate of economic return to the fishermen participating in that fishery," (2) take the allowable harvest "in an orderly, efficient manner[2] and consistent with sound fishery management techniques," and (3) "avoid serious economic hardship to those currently engaged in the fishery, considering other economic opportunities available to them." Standards for issuance of entry permits are the degree of economic dependence of the applicant upon the fishery (percentage of income derived from fishing, reliance on alternative occupations, availability of alternative occupations, amount of vessel and gear investment) and extent of past participation in the fishery. No reference is made to the relative efficiency of the applicant. As Adasiak notes in his paper, "To remove less effective fishermen could deprive subsistence-oriented communities from a significant, though perhaps relatively small, amount of cash needed for the continued functioning of those communities." (Adasiak 1979)

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[2] "Efficient manner" from further language in the Act and the context in which it was developed, refers to technological efficiency, not optimal numbers of factors.

Political Objectives of Limited Entry and the Economist

Very little has been said or written from within Alaska on the subject of economic efficiency as an objective of management, the classic work on the Alaska salmon fisheries being that of "nonresident" economists (Cooley 1963; Crutchfield and Pontecorvo 1969). This is not because "resident" economists are unaware or unappreciative of attempts by other economists to apply open access resource theory to regulatory policy, but because of the limited political feasibility of using these models in the promotion of management reform and because they are not addressed to the questions they must deal with in practice. Alaskan economist's usual clients are public agencies and their objectives have been formulated by the political process which lays stress upon employment or, more specifically, jobs for Alaskans. The conflict between efficiency and employment, however, is more apparent than real and is rooted in the definition of efficiency stated or implied in much of the literature.

In their 1969 study of "irrational conservation," for example, Crutchfield and Pontecorvo attempted to measure the cost of economic waste inherent in the open access Bristol Bay fishery as the value of the "economic rent dissipated." This was calculated simply as "the difference between the gross earnings of the entire fleet in any year and the gross earnings that would have been required at the 1942–43 efficiency level," the period with the highest recorded yield per unit of input (Crutchfield and Pontecorvo 1969, p. 110–117). The economic efficiency in this illustration was reduction of cost to the processor and, if they were lucky, the consumers through transfer of payments which would have been made to "unnecessary" units of gear. In his review of the book, Tussing stated a typical Alaskan reaction to this definition:

> "The concern with allocative efficiency is a professional idiosyncrasy of economists; the ordinary citizen assumes immobility and takes the possibility of structural unemployment very seriously. He therefore regards 'job creation' as having more merit than cost reduction. If a physical harvest which is constant over time can indeed provide opportunity incomes for ever greater numbers of fishermen, perhaps the existing organization of the resource is truly a wonderful innovation! ... The present regime might be criticized best not for dissipating potential rent but in dissipating too much of it in financing paid vacations for Seattle school teachers and Anchorage real estate men, and not enough in open or disguised welfare payments to the immobile components of the labor force." (Tussing 1970, p. 480–481)

Elsewhere in this symposium, Crutchfield appears to recognize that employment objectives might have a place in limited entry considerations, but with qualifications.

> "A considerable amount of nonsense has been written (e.g. Cicin-Sain 1978) about the impact of limited entry programs on unemployment — in the fishery, and in associated industries in coastal ports. It is hard to view this as a really serious problem in general terms. ... An important exception would be in isolated fishing communities where other employment opportunities are severely limited. It is quite possible that spreading employment in the fishery [by definition adopting somewhat less than optimal factor combinations] would still represent the least cost method of achieving some desired minimum economic and social standards. But [as reiterated by many economists] this is a matter to be determined by study, not simply assumed." (Crutchfield 1979).

Both points of view are valid in the political setting of management practice. If the economist is to avoid the appearance of "idiosyncratic behavior" associated with exclusive concern with a narrowly defined efficiency, however, the remedy is not the writing of "nonsense" on employment and social standards but, as Crutchfield suggests, through expanding the scope of economists' study to include regional problems of employment and immobility along with those subjects that have been the dominant concern of the literature of the past two decades. In the words of a commentator on this paper,

> "If labourers are, in fact, not moveable or retrainable or combinable with other more mobile factors of production, then economic efficiency may dictate the maintenance of the less competitively capable fishermen at the expense of the more successful fishermen. In this sense the extension of economics research into employment, labor mobility, etc. can be viewed in part as necessary to the evaluation of opportunity costs and economic efficiency."

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Limited Entry in the Western Australian Rock Lobster and Prawn Fisheries: An Economic Evaluation[1]

T. F. MEANY

Fisheries Division, Department of Primary Industry, Canberra, A.C.T. 2600, Australia

MEANY, T. F. 1979. Limited entry in the Western Australian rock lobster and prawn fisheries: an economic evaluation. J. Fish. Res. Board Can. 36: 789–798.

Limited entry was first introduced into the rock lobster and prawn fisheries in 1963. Both fisheries have been characterized by rapidly rising prices for species caught. Although some sectors of the rock lobster fishery have remained moderately profitable, excessive reinvestment in boats and equipment has greatly reduced potential profitability. No trend towards company ownership of boats has been evident in this fishery. The prawn fishery was initially developed with a high degree of company ownership and the proportion of company ownership has increased. Overcapitalization has not occurred to any great extent in this fishery and profitability has remained high.

Key words: rock lobster, prawns, limited entry, Australia, economics, overcapitalization, monopoly

MEANY, T. F. 1979. Limited entry in the Western Australian rock lobster and prawn fisheries: an economic evaluation. J. Fish. Res. Board Can. 36: 789–798.

L'entrée limitée fut introduite pour la première fois dans les pêcheries de langoustes et de crevettes en 1963. Ces deux pêcheries ont été caractérisées par une hausse rapide des prix pour les espèces capturées. Bien que certains secteurs de la pêcherie de langoustes soient demeurés modérément rentables, le potentiel de rentabilité a été grandement réduit par un réinvestissement excessif dans les bateaux et l'équipement. Il n'y eut pas dans cette pêcherie de tendance marquée vers la propriété de bateaux par les sociétés. La pêcherie de crevettes connut dès ses débuts un haut degré de propriété par les sociétés et cette condition s'est accentuée. La pêcherie n'a pas connu une surcapitalisation trop forte et est demeurée très rentable.

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THE term limited entry as used in this paper refers to fisheries in which no additional boats are allowed to operate. A decision to implement limited entry is generally achieved in Australia by endorsing the licenses of those with a history of involvement in the fishery and excluding all others. New fishermen can then enter the fishery only by buying a boat with a current license endorsement. Limited entry has been in force in some Australian fisheries for over 15 yr. Entry to the majority of the nation's most important fisheries is now restricted. In general, these restrictions have been well accepted by fishermen.

The Western Australian Rock Lobster Fishery

Rock lobster (*Panulirus longipes cygnus*) have been fished in Western Australian waters since the early days of settlement. It was not until the 1950s, however, when the United States market for frozen rock lobster tails was developed that the fishery became heavily exploited. As fishing pressure increased a series of management measures were introduced to safeguard the resource. The price paid for rock lobster was increasing rapidly at the time and there was a continuous influx of fishermen into the fishery. Each measure offered only a temporary respite from the growth in fishing effort.

By the early 1960s considerable pressure was exerted on government, by industry, to restrict further entry to the fishery, because although the number of rock lobster pots in use increased by 66% between 1958–59 fiscal year and 1961–62, the increase in catch had only been 8% (Bowen 1973). Part of the problem confronting administrators was related to the use by fishermen of an excessive number of rock lobster pots. In 1963 further restrictions were introduced. These "froze" the number of licenses at the existing level (about 830) and limited the number of pots a fisherman could use to three for each foot of boat length with a maximum of 200 per boat. To prevent fishermen exploiting loopholes in the system, additional restrictions were shortly thereafter introduced which virtually prohibited the

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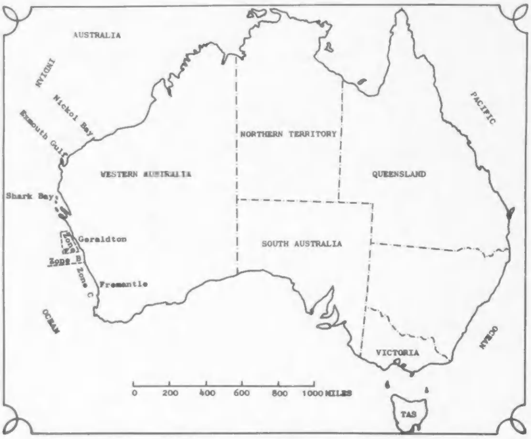

FIG. 1. Fishing zones.

replacement of boats under 8 yr of age and restricted replacements to boats of the same length as the ones being replaced.

Additional management measures in force in the fishery include fishing zones as illustrated in Fig. 1, a closed season in all areas from August 15 to November 14 and in zone A from November 15 to March 14 (boats with endorsements for zone A operate mostly in zone B during this period). A minimum rock lobster size operates in all areas and the taking of berried (egg-carrying) females is prohibited. Each rock lobster pot is also required to be fitted with an escape gap of regulation size. Possibly the greatest deterrent to the breaking of regulations rests with the power to suspend the license of a fisherman convicted of an offence.

OBJECTIVES OF MANAGEMENT

The stated objectives in the management of the fishery are briefly summarized as follows (B. K. Bowen unpublished data): (i) optimum utilization of the resource, (ii) reasonable economic returns to fishermen, and (iii) orderly fishing.

From this it can be seen that the objectives include biological, economic, and social components. The social objectives in particular make the assessment of the success of restricted entry from a purely economic viewpoint more complicated.

ECONOMIC CONSIDERATIONS

The fishery has been the subject of a series of economic studies, the first in 1956 (Taylor 1956), then in 1963 (Anon. 1964), in 1969 (Anon. 1974), and 1975 (Anon. 1976). In Fig. 2 the annual catch from the fishery has been plotted against the approximate number of boats. Unfortunately until the introduction of restricted entry the number of boats in the fishery was not accurately known. Figure 1 shows that the annual catch from the fishery rose rapidly until about 1958–59; since then the catch has fluctuated between about 16 and 20 million lb/yr. Boat numbers increased rapidly until restricted entry was introduced in 1963.

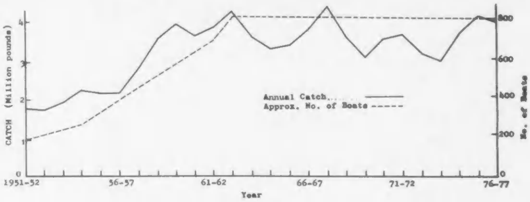

FIG. 2. Western Australia rock lobster fishery — annual catch and approximate fleet size 1951–52 to 1976–77.

The fishery extends more or less continually over several hundred miles of coast, with boats operating out of ports scattered along its length. Many of these are not ports in any real sense of the word but merely anchorages which provide safe shelter in most conditions. Most of the boats are small and can be beached with little difficulty if bad weather threatens.

These conditions, together with the relatively small capital outlay required for rock lobster processing and the requirement that the rock lobster must be alive at the commencement of processing, led to the establishment of a number of processing companies and plants. Although there has been some rationalization with larger companies acquiring some of the smaller plants, there are still a significant number of companies involved in rock lobster processing. The greater part of the catch is, however, handled by seven or eight main companies, including two large and one smaller co-operative.

The price paid for rock lobster is determined by the United States market for rock lobster tails, over 90% of the catch being exported to that market. The price paid to fishermen has shown a generally upward trend (Fig. 3). This trend has not been uniform, however. The tendency has been for the price to rise rapidly for a year or two and then be followed by a period with steady prices or even a slight fall. The periods of rapid price rise have been periods of high profits for the industry while in the intervening periods costs have

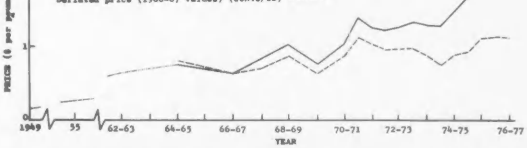

FIG. 3. Average rock lobster prices, 1949 to 1976–77, in money and constant 1966–67 values.

TABLE 1. Average catch and profitability, by zone 1962–63, 1966–67, 1967–68, 1968–69, 1972–73, and 1973–74 and average annual earnings in Western Australia for those years.

	1962–63[a]	1966–67	1967–68	1968–69	1972–73	1973–74
		Zone A				
Avg catch (lb)	29 197[a]	23 662	24 239	23 142	25 988	22 985
Gross income ($)	11 737	15 864	20 423	23 096	27 459	27 407
Total costs ($)	7 246	9 136	8 976	9 924	16 426	17 107
Return to owner–skipper ($)	4 491	6 728	11 447	13 172	11 033	10 300
		Zone B				
Avg catch (lb)[a]		19 246	21 599	18 332	15 791	16 175
Gross income ($)		14 310	19 210	22 365	19 466	19 860
Total costs ($)		8 472	8 880	10 513	12 228	11 836
Return to owner–skipper ($)		5 838	10 330	11 752	7 238	8 024
		Zone C				
Avg catch (lb)	31 097	29 435	31 442	22 841	20 249	17 460
Gross income ($)	12 176	18 792	25 916	23 650	24 890	22 253
Total costs ($)	9 963	11 798	13 165	12 614	16 633	16 647
Return to owner–skipper ($)	2 213	6 994	12 751	11 036	8 257	5 606
Avg annual earnings per employed male in W.A. ($)	2 306	3 088	3 344	3 600	5 165	6 026

[a]Zones A and B were combined in this study.

tended to outstrip prices resulting in reduced profitability.

Figure 3 shows the price paid to fishermen in constant dollars with 1966–67 the base year, the Consumer Price Index being used as the deflator. It can be seen from this that between 1969–70 and 1971–72 the price for rock lobster in constant 1966–67 values rose from 65¢ to $1.03/lb. Between 1971–72 and 1974–75, on the other hand, the rock lobster price in constant 1966–67 values declined from $1.03 to 82¢/lb. This illustrates the fluctuating fortunes of those in this fishery.

Despite these price fluctuations the fishery has remained generally profitable. In Table 1 the average catch, gross income, total costs, and return to owner–skipper are shown for each zone for a series of years.

Average catches and profitability have shown different trends in each zone the most marked difference being between zones A and C. In zone A average catches have remained stable and the increase in the price of rock lobster has offset increased costs. In zone C, however, average catch has declined resulting in a marked decrease in profitability. A comparison of Table 1 with Fig. 3 shows that 1966–67 to 1968–69 corresponded with a period of rapidly rising prices resulting in increasing profitability. By contrast, in 1972–73 and 1973–74 prices were declining in real terms.

Costs shown in Table 1 are exclusive of interest paid on borrowed money. With the rapid increase in sophistication and capital investment in boats, as discussed later, there has been an increase in the need to borrow money to finance fishing operations. In addition, the market value which now attaches to rock lobster licenses has meant an additional cost which must be met by those entering the fishery.

Lending institutions, however, view limited entry fisheries more favorably than open entry fisheries and are therefore willing to advance a greater proportion of the cost of investment in the fishery than would normally be expected. All this suggests that many in the fishery are heavily committed to the repayment of principle and interest on sizeable loans. Most of these loans would have been contracted in times of increasing profitability (eg. 1970–71 to 1971–72) and were no doubt negotiated on the expectation that those levels of profitability would continue. With the downturn in profitability in 1972–73 to 1974–75 these commitments must have placed a heavy financial burden on many fishermen.

BOAT OWNERSHIP

It is often claimed that one side effect of limited entry can be the development of company-owned fishing fleets, as companies can, in general, outbid individuals for any boats that may be for sale. Throughout the history of the rock lobster fishery over 90% of the fleet has been owned either by individuals or by partnerships of from two to four people. Public companies own only a small percentage of the fleet. There are no indications that this situation is changing.

This does not, however, necessarily disprove the hypothesis that license limitations can lead to the decline of individual ownership. As has been mentioned, the fishery is characterized by the existence of a number of competing processors and companies found that many employed skippers were not adverse to selling a large proportion of the catch to other than the owner

TABLE 2. Changes in selected boat characteristics 1963, 1969, and 1975.

Characteristic	1963	1969	1975
BHP of engine	70	100	172
Planing hulls (%)	29	50	62
Fiberglass hulls (%)	1	1	16
Plywood hulls (%)	27	56	45
Planked timber hulls (%)	66	38	34
Echo sounders	68	88	99
Radio transceivers (%)	18	88	98
Automatic pilots (%)	NIL	8	33

of the boat (usually a processing company). Likewise employed skippers were often not as dedicated as owner–skippers and did not maintain boats in the same condition.

SALE OF ROCK LOBSTER LICENSES

No attempt has been made in this fishery to impose artificial restraints on the sale of boats and there is virtually unrestricted sale of boats with rock lobster licenses. Quite naturally before limited entry was introduced in 1963 the license to fish had no transfer value. By 1969 the average value of a boat and license was about $27 000 while at the same time the average boat, without the license, was valued at only about $10 000. Between 1969 and 1975 the average value of a boat and license had increased to about $36 000 while average value of the boat without the license had risen to about $14 000. It has, however, been noted in this and other limited entry fisheries that the value of licenses is anything but stable and can fluctuate quite widely with downturns and upturns in profitability.

As well as restrictions on the number of boats licensed, there are also regulations governing the replacement of boats, regarding size and age of boats which can be replaced. However, these restrictions have not prevented a considerable change in the fishing fleet which must have added to the technical (although probably not the economic) efficiency of fishing.

Despite all the restrictions on boat replacement Table 2 demonstrates a considerable increase in the sophistication of the fishing fleet. Undoubtedly the profitability of the fishery has contributed substantially to this rapid technological change. There would appear to be two factors at work here. There are no doubt many fishermen, often among the most successful, who take pride in having the latest in equipment; these fishermen, by increasing their technological efficiency, can increase their total catch and hence their gross income. It is difficult to determine to what extent these fishermen are concerned with increasing their net incomes. Many fishermen in this group of innovators are already well established financially and appear to be motivated as much by the desire to demonstrate their ability as fishermen as to increase their profits still further. If this is so then they will be prepared to deliberately overcapitalize to achieve their objective.

As the fishery is already fully exploited any increase in catch by one group of fishermen means that there is less rock lobster available to the remainder. As the cost of taking this smaller catch remains unaltered, this means a reduction in net income. These fishermen must therefore match the technology of the innovators if they are to remain competitive. There is little doubt that these two factors are the prime cause of the trends illustrated in Table 2. Of particular relevance in this table is the change from displacement hulls to planing hulls.

The type of fishing involved lends itself to small boats and few boats in the fishery are larger than 45 ft long, the vast majority being between 25 and 45 ft. In zone A much of the area fished consists of shallow reefs and high speed planing hulled boats locally called "scooter" boats evolved in this area. Because of their greater speed and ability to work more remote grounds in shorter times, this type of hull has become more popular and almost all replacement boats now entering the fishery, regardless of size, are of this type. The greater power required to propel a planing hull largely explains the increase in average horsepower.

There has been a slight increase in the average age of boats — in 1962–63 this was 8 yr, by 1969 this had increased to 10 yr and by 1975 to 11 yr. In 1963 about half the fleet was under 5 yr old (representing the rapid increase in the fleet immediately before the introduction of restricted entry). By 1969 this percentage had dropped to 25%. However, by 1975 this had increased slightly to 27%, despite the fact that only 8% of the fleet was under 4 yr old. This decrease in building activity after about 1972 reflects the reduction in profitability which occurred at that time due to the downturn in prices. In 1975 48% of boats were in fact between 4 and 9 yr old.

The effect of profitability on the decision when to replace a boat is illustrated by comparing the situation in zones A and C. In 1969 both these zones were returning very good profits. At this time 26% of the boats in zone A were under 5 yr old and in zone C 24%. In 1975 zone A was still producing quite reasonable profits while those in zone C were the cause of some concern. By that year the percentage of boats in zone A under 5 yr old had risen to 34 while in zone C it had declined to 21%.

Although there was reduced investment in all areas of the fishery between about 1972 and 1975, the increase in profitability due to the higher prices received since then has resulted in a renewed round of boat replacement.

Investment in new boats and equipment represents far more than normal replacement and updating. The fishing method used is relatively a simple one requiring only a basic fishing platform. Boats now in the fishery are far from basic and are fitted more in keeping with what one would expect of the well-to-do sport fisherman than of the professional fisherman. Spending on boats can best be described as conspicuous.

SOCIOLOGICAL CONSIDERATION

The great majority of fishermen in the rock lobster fishery have no family history in fishing, indeed the greater proportion of them came to the fishery from other occupations, many being skilled or semiskilled tradesmen. In general ethnic background they appear to represent a reasonable cross section of the Australian community with a majority Australian by birth but with a reasonable number of migrants, mainly from the United Kingdom and Northern Europe.

An exception to this general situation is found in the port of Fremantle (in zone C) where a large percentage of fishermen are Italian. This group tends to differ from others in the fishery in several ways; first, they tend to operate their boats as family units with most members of the crew related, secondly they tend to use what I have seen referred to in U.S. publications as the "Italian lay" system of payment, with each crewman taking an equal share after a certain percentage had been set aside for the cost of running the boat. Elsewhere in the fishery crewmen are paid mainly a fixed rate per 100-lb bag of rock lobster landed. Probably because they were family units these Italian boats tended to carry larger crews than those found on similar-sized boats elsewhere in the fishery. With the drop of profitability in zone C it was, however, noted in 1975 that this differential in crew size had disappeared.

One interesting feature of the fishery relates to the average age of skippers. In 1963 this was 41 yr. With the introduction of restricted entry it is reasonable to expect that this average age would tend to increase. This has not occurred, however, as in both 1969 and 1975 the average age was 42 yr. This without doubt results from the high prices offered for rock lobster licenses enticing many out of the fishery into other avenues of employment before they reach normal retiring age.

LICENSE FEES AND RESOURCE RENT

License fees in the fishery are minimal, boat licenses and fishermen's licenses costing only a few dollars each. The most significant fee is an annual license fee of \$3.50–\$4.00 per pot (the fee differs between zones). This fee could be as high as \$800/yr for a boat with the maximum entitlement of 200 pots. (These are 1978 charges and must be looked at in the light of 1978 prices.) However, in view of the level of profit this hardly represents an attempt to appropriate a substantial part of the resource rent available from this fishery. This has contributed towards fishermen making what can probably be termed excess profits, and this has in turn contributed to gross overcapitalization and excessive fishing effort.

Some very rough calculations I made following the 1969 study showed that if boat numbers were reduced to approximately the 1959 level (when the annual catch from the fishery reached 18 million lb), and assuming (i) some relaxation of the three pots per foot rule and (ii) a recovery of the catch per unit of effort to midway between its 1959 and 1969 level, after allowing a reasonable payment for the skippers labor and a 25% return on original investment, a resource rent of \$7 million/yr could have been taken from the fishery.

GROWTH IN FISHING EFFORT

Before the introduction of restricted entry in 1963 there had been a rapid increase in fishing effort with a rapid rise in the number of boats and rock lobster pots used. A closed season has operated corresponding with the season of reduced availability of rock lobster.

Fishing is, however, concentrated in a much shorter season, for example in 1969 it was noted that 94% of the catch in zone C was taken in the $5\frac{1}{2}$ mo from November 15 to April 30. Likewise boats in zone A took 87% of their total catch in two periods totalling only 4 mo (from November 15 to December 31 while operating in zone B and from March 15 to May 31 in zone A). There were indications at the time that boats, particularly the smaller ones, were extending their fishing season and that even at the lower catch rates being taken in the remainder of the season most boats could still fish quite profitably. This trend has apparently continued and the rock lobster season in 1978 was closed 6 wk earlier, on June 30, instead of August 15 as in previous years.

The reasons given (Anon. 1978) for the new restrictions were "In recent years there has been a gradual increase in fishing pressure due to the introduction of faster boats and more efficient catching gear and methods. As a result the number of days worked each season by lobster fishermen has increased correspondingly. Fishing effort was producing an annual exploitation rate of about 70 per cent of all legal sized rock lobsters. This meant that the fishery is heavily dependant on annual recruitment to legal size." Research had indicated "that effective fishing effort had risen to levels similar to those prior to 1963 when pot restrictions were introduced."

The length of the existing closed season has already created a crew recruitment problem in some sectors of the industry. The additional 6 wk must add to this. It may also mean that more owner–skippers will have to seek work ashore during the closed season. The decision to extend the closed season highlights the deficiencies in the system of "freezing" numbers. Such a step slows down but does not stop the growth in fishing effort. Without some mechanism for reducing boat numbers the necessity for additional measures of "regulated inefficiency" would appear to be in the long term inevitable.

SUMMARY

There can be no doubt that without the introduction of limited entry the number of boats in the rock lobster fishery would have increased well beyond the 830 level. This would have placed severe pressure on the resource and resulted in very great problems in restricting fishing effort using other methods. It would also have created even greater problems in policing these restrictions. The introduction of restricted entry has given the fishermen involved a period of high and relatively stable incomes which could not have been attained under open entry.

Restricted entry has not, however, prevented effective fishing effort in the fishery from increasing. Indeed it would appear that the reinvestment in the fishery of the high profits available under restricted entry has been probably the major cause of the growth in effective fishing effort.

The success of limited entry in this case has also been influenced by the fact that prices paid for rock lobster have increased faster than costs and that high profits were in fact maintained despite a substantial increase in costs. Had prices risen at the same or at a slower rate than costs, the situation in the fishery would be very different. The fishing would certainly be less profitable, but because part of the increasing level of costs was associated with overcapitalization encouraged by high earnings, this does not necessarily mean that it would have been an unprofitable fishery. It does mean that the fleet structure would be different.

Limited entry in the rock lobster fishery has, especially in the eyes of fishermen, been very successful. Returns have in general remained attractive. This has resulted in boats licensed to fish rock lobster acquiring values greatly above the value of the boat itself. This is clear evidence that without limited entry there would be a great increase in the number of boats in this fishery.

There is also little doubt that even at the beginning of limited entry in this fishery the number of boats was far in excess of that required to take the available catch. Restrictions on fishing effort proved only partially successful with the result that it has been necessary to extend the closed season. The high levels of profit and competition between fishermen have resulted in a excessive reinvestment of profits in ever more sophisticated boats and equipment. This trend not only increased the fishing pressure on the resource, but also reduced the economic rent available from the fishery.

To date there has been no worthwhile attempt to appropriate any of the resource rent from the fishery. Had this been done it would seem certain that the rate of growth in potential fishing effort and dissipation of the resource rent would have been much slower. The failure to appropriate any of the resource rent has also led to a feeling among fishermen that they have collective ownership of the resource. I believe it would be most difficult politically to attempt to appropriate any part of resource rent now.

The Western Australian Prawn (Shrimp) Fisheries

The existence of commercial quantities of prawns in Shark Bay was first established in 1952. Development of the fishery was slow, however, due to the remoteness of the area, the absence of processing plants, and the shortage of suitable boats. To reduce the risks associated with investment in this remote area the Western Australian government offered two processing companies exclusive rights to shore-based processing in the fishery in 1963. In addition, it restricted to 25 the number of licenses issued, 15 of which were given to the two processing companies. (One processing company later purchased the assets of the other to give it exclusive shore-based processing rights.)

Following the discovery of commercial quantities of prawns in Exmouth Gulf, 17 licenses were issued in 1965, 13 of which were to the two processing companies given exclusive rights for shore-based plants. This same philosophy was followed in 1971 when restricted entry was extended to Nickol Bay. Here 13 concessions were issued, all to two processing companies.

In all areas the number of licenses is reviewed every 3 yr and additional licenses are issued if biological and economic data suggest that such a course is prudent. When additional licenses are issued they are provisional for the 1st 3 yr; when evidence gathered in this period confirms that the additional licenses have not had adverse effects, they acquire full status. There are now 35 licenses in the Shark Bay fishery, 22 in Exmouth Gulf. No additional licenses have been issued in Nickol Bay.

Because limited entry has been in force since the beginning of these fisheries, there has been no need for other measures designed to restrict fishing effort. Apart from limited entry the only management measures in force are closed nursery areas and closed seasons over part of the grounds for part of the year to permit prawns to grow to an acceptable market size. There are no restrictions on mesh sizes or minimum size of capture, nor are there any restrictions on the replacement of existing boats. However, boats are not permitted to operate more than two nets at a time.

MANAGEMENT OBJECTIVES

The stated objectives for the management of these fisheries are as follows (Bowen 1973): (i) economic viability of fishing units, (ii) economic viability of processing establishments, (iii) prevention of overexploitation of the prawn resource.

A comparison of this with management objectives in the rock lobster fishery indicates more concern with economic and less with social considerations in the prawn fishery. The difference in emphasis is undoubtedly related to the different histories of the two fisheries, the management objectives in the prawn fisheries being greatly influenced by the initial decisions taken to assist the development of the fishery.

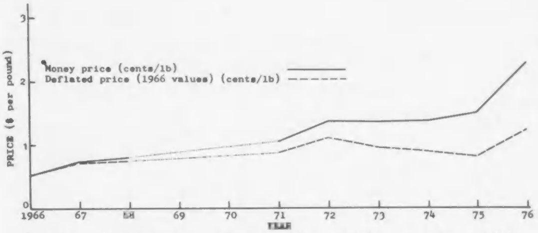

FIG. 4. Average annual price, king and tiger prawns, 1966–76, in money and constant 1966 values.

TRENDS IN THE FISHERY

The price paid has followed the general world trend for prawns and shrimp and has shown a strong upward trend throughout this period. The average price paid for king and tiger prawns is shown in Fig. 4 which also shows this price trend in constant 1966–67 values (the Consumer Price Index has been used to deflate dollar values). Between 1966 and 1972 the price paid for prawns showed a constant upward trend in both dollar and real values. Between 1972 and 1975 prices showed little change in dollar values and actually decreased in real terms. Since 1975 prices both in real and dollar values have shown a strong upward trend.

Annual production from Shark Bay, Exmouth Gulf, and Nickol Bay are shown in Fig. 5. The annual catch from Shark Bay has shown a steady upward trend. While also showing an upward trend, the Exmouth Gulf catch has shown much greater variability while Nickol Bay has shown great year-to-year variability. Table 3 shows the Gross income, costs, net income, and percentage return on capital for Shark Bay and Exmouth Gulf over a series of years. The value of capital used in calculating percentage return is the market value exclusive of any value attaching to the license. This table shows that high returns were earned in both fisheries in most years, although Exmouth Gulf showed much greater variability than did Shark Bay.

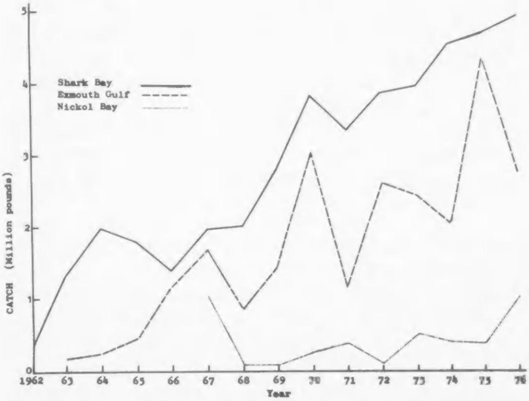

FIG. 5. Annual prawn catch, Shark Bay, Exmouth Gulf, and Nickol Bay, 1962–76.

The fisheries were initially developed mainly by converted rock lobster boats. Even by 1968 when the first economic survey was carried out many of these had been replaced by purpose-built prawn trawlers. In Table 4 the trends in the fishing fleet are illustrated. It might be kept in mind that there are no artificial restraints on boat replacement in this fishery — each owner decides when he will replace a boat, the size of that boat, and the equipment it will carry.

In 1968 no boats were recorded as carrying radar, by 1974 about two thirds of the fleet carried this equipment and by 1977 all boats. In 1968 the boats were about equally divided between planked timber and steel hulls, by 1977 there were only three planked timber boats remaining in the two fisheries. In 1968 about half the boats in Shark Bay and all the boats studied in Exmouth Gulf were single rigged. In 1977 all boats were doubled rigged, indicating quite clearly that there has been a continuing development in the technical efficiency of the fleet.

However, although there are no constraints on boat replacement, there has been no tendency in recent years for the size of boats in the fishery to increase. In Exmouth Gulf for example all boats are between 58 and 66 ft long; in Shark Bay only the older boats are outside these limits. This suggests a tendency towards a most efficient size for the fishery. The dominance of company ownership and fleet standardization must be a contributing factor, but individually owned boats appear to follow the same pattern.

The increase in average age of boats in Shark Bay is greatly influenced by company operations; 75% of boats operated by the one processing company in this fishery are between 9 and 10 yr old. In Exmouth Gulf many of the licenses issued to the processing companies were utilized by privately owned boats under contract. These have all been replaced by new, company-owned boats. This has been a major factor in influencing the average age of boats in that fishery.

Because many licenses are held by processing companies that have not been interested in selling and because there have been few recorded sales in the relatively small privately owned fleet, it is difficult to get a realistic figure for the market value of licenses. In 1973 (Bowen 1973) it was suggested that the value might be as high as $100 000. In 1977 fishermen valued the licenses at between $150 000 and $200 000.

There have been no attempts to evaluate the economic performance of the processing sector of these fisheries. The processing companies run their boats and processing plants as integrated operations. In arriving at the figures in Table 3 on boat profitability, the income of company boats had to be adjusted by using the unit price received by independent operators. For their own accounting purposes the companies paid their own boats only a nominal price. The processing companies must

TABLE 3. Average prawn catch, gross income, expenses, and returns Shark Bay and Exmouth Gulf, in selected years.

	1966–67[a]	1967–68[a]	1971–72[b]	1972–73[b]	1973–74[b]	1974–75[c]	1975–76[c]	1976–77[c]
				Shark Bay				
Prawn catch (lb)	87 300	83 300	120 810	135 532	139 322	NA	NA	NA
Gross income ($)	50 212[d]	55 051[d]	84 784	104 366	104 733	111 001	176 145	172 019
Expenses ($)	39 258	45 189	62 126	77 710	79 083	92 942	99 847	113 082
Net income ($)	10 954	9 862	22 658	26 656	25 650	18 059	76 298	59 528
Return on capital (%)	29.2	25.8	21.6	25.4	24.4	11.8	50.0	39.0
				Exmouth Gulf				
Prawn catch (lb)	92 300	84 200	114 588	140 603	160 568	NA	NA	NA
Gross income ($)	40 122[e]	45 760[e]	54 551	81 127	67 240			
Expenses ($)	29 632	34 079	54 756	59 224	55 981			
Net income ($)	10 490	11 681	loss 205	21 903	11 259			
Return on capital (%)	37.2	32.7	—	30.0	15.4			

[a] Anon. (1970).
[b] Anon. (1975).
[c] Unpublished data from economic survey conducted in 1977.
[d] Over 30% of gross income in 1966–67 and 1967–68 was from rock lobster.
[e] In 1966–67, 26% and in 1967–68, 37% of gross income came from rock lobster.

pay a market-determined price to individually owned boats as most of these, particularly in Shark Bay, have full freezing facilities and can process prawns to export standards on board and so if necessary by-pass the shore-based processor. In Exmouth Gulf the competition between the two processing plants is sufficient to ensure reasonable prices.

Although there is no legal bar to their doing so, processing companies have not attempted to establish complete monopolies by buying out individually owned boats. (This has occurred to some extent in Exmouth Gulf). While the reasons for this are not quite clear, it is probable that processing companies feel that such an attempt would result in counter moves by government. There has, however, been evidence of other companies buying up individually owned boats to establish fleet operations. Table 5 shows the number of boats in Shark Bay and Exmouth Gulf owned by processing companies, other companies (owning more than two boats), and those in single ownership in 1977.

All licenses not held by processing companies were originally issued to individual fishermen. There is therefore clear evidence of a trend towards company ownership. This would tend to support the suggestion that restricted entry can result in monopolistic tendencies in the ownership of fishing fleets.

NICKOL BAY — A SPECIAL CASE?

Apart from the initial mention that license limitation operated in Nickol Bay, little has been mentioned about that fishery in this paper. The annual catch from this fishery has fluctuated widely from year to year (Fig. 5). Thirteen licenses were initially issued in Nickol Bay but there has been no year since then that all these boats have operated.

TABLE 4. Trends in the fishing fleet, Shark Bay and Exmouth Gulf.

	Shark Bay			Exmouth Gulf		
	1968	1974	1977	1968	1974	1977
Length of hull (ft)	55	64	64	48	61	62
Age of hull (yr)	8.3	7.5	10.0	6	6	6
Engine power (BHP)	148	272	283	162	263	321

One basic problem with this fishery is obviously the large 1967 catch and the progressive increase in catch from 1968 to 1971 when restricted entry was introduced. This must have given the impression of a much more substantial fishery than subsequent events have indicated. The main species caught in this fishery is the banana prawn, *Penaeus merguiensis*, which is subject to much greater fluctuations in abundance than are the western king prawn, *P. latisulcatus*, and the tiger prawn, *P. esculantus*, which are the main species in the Shark Bay and Exmouth Gulf fisheries.

At the time of the 1974 economic surveys of the Shark Bay and Exmouth Gulf fisheries, an attempt was made to include the Nickol Bay fleet. This attempt was

TABLE 5. Ownership of boats, Shark Bay and Exmouth Gulf 1977 percentage of total.

	Processing companies	Non-processing companies	Individually owned
Shark Bay (%)	55	24	21
Exmouth Gulf (%)	75	15	10

abandoned, however, because of the difficulty in contacting fishermen and the poor records kept by those who could be contacted. The clear impression was that this fishery returned a low level of profitability.

I would argue that when a fishery fluctuates as much as does the Nickol Bay fishery, limited entry as it now operates in this fishery is not an appropriate management measure. Unless the number of boats permitted entry is at a level that is based on catches in poor years, restricted entry cannot hope to give economic stability. However, if this is done then much of the catch in peak years must be wasted. Fluctuating fisheries particularly in remote areas are not generally subject to the same demand for entry as are more stable fisheries and the potential benefits of limited entry are therefore not as great. Unless it is feasible to combine more than one such area in the same limited entry regime, it would seem that open entry would at worst cost little more and could result in some economic gain.

RESOURCE RENT

As with the rock lobster fishery there has been no real attempt to appropriate part of the resource rent. Licenses for this fishery cost $1500/yr for Shark Bay, $1250 for Exmouth Gulf, and $200 for Nickol Bay. In view of the levels of profitability in these fisheries, this must be regarded as a nominal amount. It certainly does not represent what might be considered a significant part of the resource rent available. Although the number of processing plants is also restricted, license fees charged for them are also nominal, being only a few hundred dollars per annum.

SUMMARY

In terms of the management objectives set out for these prawn fisheries, the strategy adopted must be acknowledged as successful, at least in respect to Shark Bay and Exmouth Gulf. Development of the fisheries has been at a controlled rate and without the overcapitalization characteristic of many open entry fisheries.

The privileged position given to the processing companies, both with regard to exclusive shore-based processing rights and a substantial proportion of the fishing concessions, contributed substantially to the initial development of the fishery. By reducing the number of different interests making investment decisions with respect to the fishery, it has also kept capital investment at a level appropriate to the size of the resource. Management of these fisheries has, in fact, approached the suggested economic ideal of private ownership (Scott 1955) and the rationalization of inputs, which it has been suggested this approach could achieve, has, in fact, occurred. The major objection that can be raised to the present management structure is that it has not attempted to appropriate a greater part of the resource rent.

Evaluation of Management

Two decisions have had significant impact on the management of these fisheries: (i) the introduction of limited entry from the early stages of development and (ii) the issuing of a high proportion of licenses to processing companies with exclusive shore-based processing rights.

The first of these has resulted in the almost total absence of regulations designed to prevent overfishing, while the second has resulted in a system with a degree of monopoly control sufficient to prevent overcapitalization in both the fishing and processing sectors. Limited entry has been accompanied by a trend towards company ownership of boats. This may be an artifact of limited entry or it may be a natural trend dictated by the remoteness of the area and the economies of scale attaching to fleet operations.

This form of limited entry may, however, have resulted in considerable economic waste in that much of the potential catch was not taken in the early years of development and even now the full productivity of the fisheries is not known. It is also possible that this form of management by restricting boat numbers may have delayed the possible development of other less economically attractive fisheries in the same areas.

COMPARISON OF THE ROCK LOBSTER AND PRAWN FISHERIES

Management of the two fisheries represents two different approaches to limited entry. With the rock lobster fishery, restricted entry was introduced in a fully exploited fishery, while the prawn fisheries have been developed under a limited entry regime. The fisheries share the characteristics of using only one method with a relatively long catching season. With the exception of Nickol Bay they are also relatively stable with annual catches fluctuating within what are in fishery terms rather small limits. The fisheries are in the main very profitable, limited entry and rising prices placing the fishermen in a favorable position which could not have been attained under open entry.

The rock lobster fishery has, however, shown a strong tendency towards overcapitalization. This has not occurred in the prawn fishery. This might be a result of the predominance of individual ownership in the rock lobster fishery compared with the dominance of company-owned fleets in the prawn fisheries. The fact that limited entry has been in force in the prawn fisheries throughout their development may be a contributing factor, but it would appear to be less significant then the nature of ownership of boats.

Fisheries economists have theorized that limited entry is one way of preventing the dissipation so often observed in open-access fisheries of the potential resource rent. After 15 yr of limited entry in the Western Australian rork lobster and prawn fisheries, what conclusions can be drawn with respect to this? Certainly with regard to the Exmouth Gulf and Shark Bay prawn fisheries it is evident that there has been little dissipation of the resource rent. It is equally evident that this is linked with the strong elements of monopoly embodied in the management structure of these fisheries.

The situation with respect to the rock lobster fishery is not so clear. It is certain that a lot of the potential resource rent has been dissipated in the form of overcapitalization in boats and equipment. In zones B and C in particular it would seem that there is little rent remaining in the form of high profits. Years when fishermen make reasonable profits appear to trigger a new round of boat replacement and additional investment. In zone A, however, fishermen continue to achieve reasonably good returns. Certainly capital invested in boats and equipment is more than is needed to fully exploit the resource, but it could not be claimed that all the resource rent is dissipated.

It may be that the time lag between deciding to buy a new boat and taking delivery thereof is such that boats entering the fishery at any point of time represent investment decisions made at some time in the past. With relatively stable catches and prices tending to rise faster than costs, the appearance that all rent is not being dissipated may be illusionary. This explanation is not completely convincing, however, as there have been periods when incomes have actually fallen, yet the value of licenses has remained high.

A more reasonable explanation relates to the nature of the income flow. Income in zone A is much more predictable and without the year-to-year fluctuations noted particularly in zone C. Fishermen in zone A appear to have adjusted to a higher standard of living consistent with high, relatively stable incomes. There is, I think, a tendency for most people, be they fishermen or otherwise, to be less objective in their attitude to money when it is received in large amounts, at irregular intervals, than were they to receive the same total in smaller, more regular, amounts. This, I believe, is the chief reason why net incomes in zone A have remained relatively high. Incomes in zones B and C have fluctuated much more than in zone A. Fishermen in zone A have become more accustomed to these high incomes and are less inclined to overinvest when they have an exceptional year. For this reason I believe there may have been less dissipation of resource rent in zone A than in zones B and C. If this is so it has important implications for management, for if an objective is to improve the economic lot of fishermen, then it is necessary not only to restrict boat numbers, but also to dampen down year-to-year fluctuations in income to reduce the tendency of fishermen to dissipate the resource rent.

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Symposium on Policies for Economic Rationalization of Commercial Fisheries

PART III

Problems of Adjustment

Responses and Adjustments of Foreign Fleets to Controls Imposed by Coastal Nations[1]

WLODZIMIERZ KACZYNSKI

Institute for Marine Studies, University of Washington, Seattle, WA 98195, USA

KACZYNSKI, W. 1979. Responses and adjustments of foreign fleets to controls imposed by coastal nations. J. Fish. Res. Board Can. 36: 800–810.

Foreign distant-water fishing fleets expanded quickly during the last 15 yr and in some ocean areas accounted for a larger portion of the coastal fishery resources harvest than neighboring coastal nations. Extention of national jurisdiction sharply decreased these activities. Catch and fishing effort limitations imposed by coastal states were of particular concern for foreign fleets. To attenuate adverse effects of these restrictions, distant-water fishing operators are considering three basic and mutually complementing solutions: better utilization of their own coastal resources until now frequently neglected, shifting a part of their fleets to the open ocean fishing operations, and continuing highly restricted and reorganized fisheries in coastal zones of other nations. Fishing activities within the 200-mile economic zone involve utilization of surplus quotas allocated by coastal states, quicker development of joint venture operations with coastal partners, increased purchases of fresh fish from local fishermen, and transfer of technology and know-how mainly to the developing coastal countries. Supplies of goods and services are also accepted by foreign fleets in exchange for access rights to the marine living resources of the coastal nations.

However, all these adjustments of foreign fleets are considered an intermediate stage of the long-run trend in which the coastal state will be able to develop the resources without substantial participation of foreign fishermen. This trend is analyzed in the North Pacific distant-water fisheries development during recent years.

Key words: distant-water fishing fleets, world fisheries, foreign fishery activities, 200-mile economic zone, marine fishery resources utilization, management of foreign fleets, quota allocations, North Pacific marine fisheries

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Durant les 15 dernières années, les flottilles étrangères de pêche dans les mers lointaines prirent rapidement de l'expansion et, dans certaines régions, prélevèrent une plus grande proportion des ressources halieutiques côtières que les nations côtières elles-mêmes. Ces activités diminuèrent brusquement à la suite de l'élargissement des juridictions nationales. Les limites imposées par les États côtiers sur les prises et l'effort de pêche affectèrent particulièrement les flottilles étrangères. Afin d'atténuer les effets adverses de ces restrictions, les entreprises de pêche dans les mers lointaines envisagent trois solutions de base qui se complètent mutuellement: meilleure utilisation de leurs propres ressources côtières souvent négligées jusqu'à maintenant, détournement d'une partie de leurs flottilles vers des pêches en pleine mers et poursuite de pêcheries très restreintes et réorganisées dans les zones côtières des autres pays. La pêche dans la zone économique de 200 milles comporte l'utilisation de surplus alloués par les États côtiers, l'expansion plus rapide d'opérations en participation avec des partenaires côtiers, plus d'achats de poisson frais des pêcheurs locaux et, enfin, transfert de technologie et de savoir surtout vers les pays côtiers en voie de développement. Les flottilles étrangères acceptent également de s'approvisionner en produits et services en échange de l'accès à la ressource vivante marine des nations côtières. Cependant, tous ces ajustements des flottilles étrangères ne sont qu'une phase intermédiaire de la tendance selon laquelle l'État côtier sera en mesure de donner de l'expansion à ses pêches sans grande participation de pêcheurs étrangers. Nous analysons cette tendance, utilisant comme exemple l'expansion récente des pêches dans les eaux lointaines du Pacifique Nord.

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TABLE 1. Distribution of catch between domestic and foreign fishermen in the main world fishing areas (in thousand metric tons). Source: 1967 and 1969 (Gulland, 1973); 1972–76 (Yearbook of Fishery Statistics 1969–76).

Fishing areas	1967 (%)	1969 (%)	1972 (%)	1974 (%)	1976 (%)
Atlantic Northwest					
Domestic	2080 (52)	2110 (48)	2041 (47)	1926 (47)	1978 (57)
Foreign	1950 (48)	2250 (52)	2289 (53)	2130 (53)	1483 (43)
Atlantic Northeast					
Domestic	9063 (87)	9251 (92)	9275 (86)	10337 (87)	11822 (89)
Foreign	1281 (13)	769 (8)	1415 (14)	1480 (13)	1507 (11)
Atlantic East Central					
Domestic	748 (49)	782 (38)	1238 (40)	1589 (42)	1741 (44)
Foreign	782 (51)	1288 (62)	1907 (60)	2184 (58)	2227 (56)
Atlantic Southeast					
Domestic	1978 (75)	2289 (74)	1789 (60)	1955 (67)	1403 (48)
Foreign	662 (25)	801 (26)	1214 (40)	975 (33)	1535 (52)
Pacific Northeast					
Domestic	476 (46)	391 (38)	521 (19)	486 (21)	616 (26)
Foreign	569 (54)	643 (62)	2255 (81)	1831 (79)	1793 (74)

RECENT events — the widespread implementation of extended national jurisdiction, increased public concern for the protection of ocean living resources, and growing demand for animal protein in the world market — have increased the interest in utilization of the fishery resources by both coastal and distant-water fishing nations.

Since a majority of coastal states have already restricted free access to their fishing grounds, making the foreign long-range fleets the principal losers of the new ocean regime, the growing conflict between coastal and foreign fishing interests has become one of the most important problems in the contemporary world fisheries.

Nations with developed ocean-going fishing fleets are facing a significant curtailment of harvesting opportunities in overseas fishing grounds where they operated traditionally, resulting in a smaller catch and reduction of employment possibilities for their vessels and fishermen. Distant-water fishing operators were forced to revaluate their goals and policies and to adjust their future development to controls imposed on formerly unrestricted fishery resources — the basic factor in the past expansion of their fleets. For coastal nations, determination of available surplus fishery resources which can be handed over to the foreign fleets and selection of appropriate allocation policies seem to be the most immediate and important task — as seen from an international perspective.

The very nature of the long-range fishing operations, coupled with the fact that they are frequently guided by distinct objectives and operate within different economic regimes, requires that coastal nations incorporate regulations with special implications into the management of their presently enclosed fishery resources. The present controls imposed by coastal states can not be considered as already being in their ultimate form. Many important elements of the new system are still being tested and the transition period in regulating foreign fisheries is likely to last many years ahead.

It is important to understand the contemporary changes in marine resources use and distribution among the coastal and overseas users. This paper applies an economic perspective to the most important expansion patterns of the long-range fishing fleets and their responses to the recent management arrangements imposed on foreign operators by the coastal nations.

Role of Long-Range Fisheries in Utilization of World Marine Living Resources

Distant-water fisheries developed during the freedom of fisheries era mainly from the beginning of the 1960s. Table 1 shows that in all parts of the world ocean, foreign fleets have been taking a significant part of the catch. At the end of the 1960s, foreign long-range fleets accounted for 7.1 million t, i.e. about 12% of the total world catch (Gulland 1973), while 6 years later it increased to 16 million t, i.e. about 20% or even more. Of that, about 11 million have been taken in enclosed fishing grounds incorporated into the exclusive rights of the developed coastal states (Elwertowski 1977).

In some areas, particularly in the Atlantic and North Pacific oceans, foreign nations harvested a larger portion of the coastal fishery resurces than neighboring local countries. This is important because with a few exceptions, the foreign long-range fleets did not exploit the lower market value species, such as those used in

TABLE 2. Volume of catch in the principal fishing areas by selected distant-water fleets during 1967–76 (thousand metric tons). (Yearbook of Fishery Statistics 1969, 1976, FAO, Rome.)

Area and country	1967	1970	1973	1975	1976
Northwest Atlantic					
German Democratic Republic	140	89	185	113	67
Federal Republic of Germany	217	206	95	80	57
Norway	59	47	71	53	43
Poland	120	216	255	188	125
Spain	290	274	181	122	80
USSR	623	813	1357	1167	853
Atlantic East Central					
Bermuda	—	—	161	—	—
France	44	54	49	56	64
Japan	169	143	113	89	65
Norway	1	92	131	12	—
Poland	46	31	34	92	129
Rumania	9	5	44	78	36
Republic of South Africa	—	350	—	—	—
South Korea	12	27	64	97	105
Spain	179	153	367	417	385
USSR	153	613	942	1106	1315
Southeast Atlantic					
Bulgaria	18	37	23	32	46
Cuba	—	21	57	54	45
Japan	147	85	138	144	118
Poland	—	—	50	76	113
Spain	227	246	217	196	201
USSR	251	423	649	420	841
Northeast Pacific					
German Democratic Republic	—	—	5	12	—
Japan	—	1391	964	1114	1140
Poland	—	—	2	59	32
South Korea	—	—	—	3	116
USSR	570	748	380	611	582
Southwest Atlantic					
USSR	678	421	6	9	49

TABLE 3. Catch tendencies of some important fish species in selected areas of the long-range fishing operations (thousand metric tons). (Yearbook of Fishery Statistics 1971–76, FAO, Rome.)

Species/Area	1971	1973	1976
NW Atlantic herring	740	487	322
NE Atlantic herring	1404	1494	856
SE Atlantic pilchard	393	473	643
NW Atlantic capelin	58	273	365
NW Atlantic redfish	276	313	181
NW Atlantic cod	1077	808	530
NE Atlantic cod	1774	1732	1854
SE Atlantic cape hake	800	906	817
NE Pacific hake	183	164	236
NE Pacific Alaska pollock	944	690	1110

bulk for fish meal,[2] but rather developed many of higher value principally for direct human consumption. For example, the majority of tuna catches are taken by long-range vessels. In the Northwest Atlantic, distant-water fleets have concentrated their effort on cod, redfish, flatfishes, herring, and other species of high demand in their local as well as international consumption markets.

Long-range fishery activities expanded quickly mainly in those marine regions where the resources were abundant and the catch rates sufficiently high to assure high production yields for the factory trawlers. This tendency is shown in Table 2 where catch volumes of the most important distant-water fleets are compared in various fishing areas during 1967–76. In the beginning of the 1970s distant-water fleets of foreign nations were able to harvest from 4 to over 4.5 million t of fish off the Pacific and Atlantic coasts of the United States and Canada. During the first years of the 1970s Japan has taken about 1.5 million t of fish per year in the USSR coastal NW Pacific waters. This trend is present in West African fishing grounds where non-African nations within a few years reached a catch volume from 1.4 million t in 1967 to over 3.7 million t in 1976.

Once long-range fishing began in a given area it developed rapidly until declining stocks, reduced catch rates, or local fishing restrictions made other opportunities more attractive (Tables 2 and 3). Long-range fisheries developed far faster than management measures could be introduced and an excess fishing effort occurred in practically all areas of operation of these fleets, resulting in substantial reduction of exploited stocks. From 1971 to 1976 alone, the total catch of NW Atlantic herring dropped by about 66% and NE Atlantic herring by 40%, although in this last area coastal herring fisheries prevailed (Table 3). At the same time, the total harvest of the South African pilchard increased from 393 000 to 643 000 t, i.e. by over 160%, while the catch of Atlantic capelin increased more than 6 times. With the reduction of fishing opportunities of traditionally harvested species of higher market value, many distant-water fishing fleets began to develop commercially less valuable species (which are more difficult to harvest and process onboard) and to distribute them in local consumption markets. When the North Atlantic herring populations could not support the increasing fishing effort of numerous coastal and long-range fleets, many of the foreign operators shifted their interest to mackerel, African sardine, capelin, and other pelagic species as a substitute for the reduced herring supplies for direct human consumption and as alternative raw material for fish meal. The same tendencies prevailed in cod–redfish versus hake–pollock fisheries.

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[2] As, for example, massive sardine catches for fish meal developed in the 1960s by the Republic of South Africa, and in the beginning of the 1970s by Bermuda in the West African fishing grounds.

During the past few years the relative and absolute growth of the catch volume of these fleets did not, however, contribute to the increment of the fish food production for direct human consumption in many states. In most of the long-range fishing nations, the drop of the volume of processing output on the factory trawlers was caused mainly by decreasing quality of fish raw material and resulted in attempts to maximize sea processing of fish caught in increasingly remote fishing grounds.

On the other hand, long-range fishing nations should be credited for the development of some important fishery resources of overseas nations, which were not formerly utilized by the local fishermen. Distant-water fishing fleets played an important role in supplying large volumes of high quality fish food products for human consumption and for animal feed in their home countries. Except for a few nations, such as South Korea, Taiwan, Thailand, Ghana, Cuba, all the distant-water fishing fleets belong to industrially developed countries of high fish consumption patterns. Many of these states also have large agricultural potential, which, if properly utilized and managed could significantly increase alternative animal protein supplies for their societies. This could greatly decrease their pressure on many enclosed and decimated fishery resources.

Impact of Catch and Fishing Effort Limitations on Distant-Water Fishing Fleets

For many countries, such as the USSR, Japan, Spain, Poland, or South Korea, extension of national jurisdiction contributed to the loss of large fishing opportunities which could hardly be compensated for with other fish harvesting alternatives. The share of long-range fleets in the total world catch is expected to decrease sharply in the near future. Catch quotas within 200-mile economic zones could shrink to only a few million tons. This perspective is presently fully realized by foreign fleets. They will be forced from now on to ask for quota allocations. The difference is that foreign fishermen will pay for these quotas in hard currency or make other contributions, i.e. their fishing vessels may be forced to accept limitations, various impediments, and regulations of the coastal states. Foreign fisheries of the coastal nations will be strictly controlled by the enforcing authorities — some Eastern writers are criticizing the surveillance system in some coastal fishery zones (Popiel 1977).

Although distant-water fishing nations have already signed many cooperative fishery agreements with coastal states, they believe that this cooperation will be only a partial and temporary solution of these difficulties. It is also admitted by foreign operators that at best these links might not be the most convenient ones, as they are of short duration and impose sometimes difficult economic conditions (i.e. supplies of vessels, land installations, etc.) which increase considerably the overall costs of long-range fisheries. However, distant-water fishing nations are interested in signing more international fishery agreements to maintain their access to the coastal fishery resources. According to the recent tendencies (Carroz 1978), there are more chances of establishing closer cooperational links in fisheries between long-range and developing coastal nations than developed ones. For example, there is no hope that Iceland would accept joint utilization of its coastal fishing grounds with British trawlers or with operators from other European countries. The same approach is becoming evident in Norway and other ECC countries. Even in the case of Canada, where some fishing companies are interested in joint harvesting operations in coastal waters of this country, it is expected that such agreements will be of short duration and will have to be renewed each year.

Taking these limitations into account and realizing that in some regions foreign fishing vessels will simply be eliminated without any possibility of compensation, it is expected that many long-range fishing fleets will soon face unemployment or partial use of their capacity.

If coastal nations will not be able to increase their catch of recently enclosed fishery resources, and long-distance fleets will not find alternative employment opportunities in still unrestricted areas, world harvest may decrease in the near future. This in turn will contribute to the rise of fish food prices in the world markets. The result would be that many distant-water fishing countries (Japan, Soviet Union, Great Britain, and others) will be forced to limit foreign fishing effort in their coastal waters and intensify their own fisheries close to their coasts. The Soviet Union is planning to increase considerably the volume of catch in its Far East coastal waters as well as in the Barents and Baltic seas (Moiseev 1977). Also, Japan intends to increase its onshore harvest, although the numerous Japanese fishing vessels that have been withdrawn from long-distance operations will not find employment opportunities in this zone (Tanaka 1977).

A. Laing, of the British Fishing Federation, in a statement in April 1977, forecasted the British volume of catch in the coastal zone of this country to be about 3.5 million t in the beginning of the 1980s.

However, there are not too many distant-water fishing nations that have similar harvesting alternatives in their home coastal waters. Japan will lose about 4 million t of yearly catch without the possibility of any compensation in its coastal zone. The Soviet Union, with the introduction of the 200-mile economic zone, will also not be able to make up for a loss of about 4 million t of fishery resources taken annually in foreign waters (see Table 2). Poland, with its 1977 yearly harvest of about 800 000 t, will be able to take up to 200 000 t in the Baltic Convention area, while the rest must be taken outside the Baltic Sea.

Enclosure of the continental shelf fishery resources has also created a serious problem in fully utilizing the

TABLE 4. Tonnage of fishing vessels and support ships (over 100 GRT each) of the most important fishing nations in 1974 and 1976 (in thousand GRT). (Lloyd's Register of Shipping Statistical Tables 1976.)

	1974			1976		
Country	Fishing vessels	Support vessels	Total	Fishing vessels	Support vessels	Total
USSR	2 805	2 806	5 611	3 191	3 032	6 223
Japan	1 038	217	1 255	1 007	184	1 191
Spain	496	13	509	581	13	594
USA	351	7	358	415	9	424
Poland	220	51	271	245	75	320
Korea (South)	133	14	147	227	52	279
Norway	184	19	203	199	19	218
France	190	6	196	202	6	208
East Germany	103	44	147	103	44	147
Subtotal	5 520	3 177	8 697	6 170	3 434	9 604
World total	7 334	3 349	10 683	8 241	3 607	11 848

existing distant-water fishing and support fleet potential of many states. In Japan, as many as 1054 vessels including 555 salmon ships, 205 herring trawlers, 57 medium size trawlers (Hokutensen), and other vessels have been curtailed as a result of the USSR and U.S. economic zone extentions in 1977 (U.S. Embassy 1977).

Implementation of the 200-mile economic zone in the European Economic Community seas has curtailed the employment opportunities of about 500 Spanish vessels traditionally catching in these waters. Approximately 1 million workers in Spain engaged in land processing and other support activities will be affected as a result of these restrictions (Pesca 1978). Poland had to scrap about 30 older middle-size trawlers usually employed in the North Sea waters. According to preliminary estimates, all 1977 quota allocations for Poland could be taken with about 50% of the existing long-range fishing potential in this country. In the German Democratic Republic, Bulgaria, Rumania, and Cuba excessive capacity is a similar problem. It should be stressed that distant-water fleets of these countries are quite new, their average age being about 10 yr. In 1976, the total GRT of the Soviet distant water fleet (including support vessels) was about 6 223 000 t (Table 4) and in only 2 yr (1974–76) had increased about 612 000 GRT, i.e. 11%. The whole Soviet bloc fishing fleet capacity accounts for nearly 60% of the total world fishing tonnage (ships over 100 GRT each). A large part of the Eastern fleet represented by hundreds of catchers, freezers, factory-trawlers, and other specialized fishing vessels could have considerable difficulty in being utilized when fishery activities in the traditional fishing grounds are suspended or sharply reduced by the coastal nations. In this context the Soviet bloc fleet will undoubtedly suffer the greatest loss.

Objectives and Problems in Management of Distant-Water Fleets in Coastal Zone Fisheries by Foreign Operators

It has been repeatedly observed by fishery economists that the economic goals and objectives of long-range fisheries could differ greatly from those that govern the coastal state policies in the management of their fishery resources (Crutchfield 1974; Gulland 1973; Niegolewski 1974). Looking at the expansion process of the distant-water operations, it is possible to distinguish two basic economic factors — capital and manpower — which have played an important role for many foreign fishing nations during the era of unrestricted fisheries. In many nations, particularly those of centrally planned economies, the expansion of long-range fishery activities was undertaken with the understanding that an increase in fish food supplies in their consumption markets would depend upon additional investments in the construction of more fishing vessels and in employment of additional fishermen. The development of harvesting potential in these states, however, was carried out at the expense of the development of their land infrastructures (including port facilities, land processing capacity, distribution networks, etc.). Consequently, increasing yearly catch volumes of long-range fleets not always reflected increased fish food consumption rates in their home markets (Kravanja 1976).

After implementation of the 200-mile economic zone, the deciding factor in fish food availability for the distant-water fishing nations became the access to the overseas fishery resources. This factor has a strongly political character since the volume of foreign catch now depends on coastal states decisions. The quota allocations are established not only on biological, legal, or economic criteria, but also on many political considerations. Foreign fleets operations suddenly have become highly dependent upon the political relations between coastal and overseas nations which are subject to many changes even in a short time perspective. This factor makes the development of future long-range activities extremely difficult. In many cases foreign quota allocation are dependant on diplomatic relations or intergovernmental agreements between coastal nations and foreign fleets (USSR–South Korea, U.S.–Cuba, ECC–Soviet bloc states, etc.) rather than on traditional fishing rights as advocated so strongly by many long-range fishing nations. In granting access to the coastal fishery resources, preference is given today not to the states that possess developed long-range fishing potential, but rather to those that offer reciprocal fishing rights in their own coastal waters (USA–Mexico, ECC countries–Soviet Union, etc.). With growing restrictions imposed by coastal nations on the activities of the distant-water fishing fleets, foreign nations actually face two basic problems: (a) how to utilize the existing fishing potential of their long-range vessels within the framework of new legal and political regimes governing their traditional fishing grounds; and (b) what should be the direction of further development of their distant-water fisheries?

Since the majority of the long-range foreign fleets are designed for fishing operations on the continental shelves, and since their alternative open ocean fishery resources are still insufficiently explored, the main task for these fleets is to find further opportunities in the fishing zones of the coastal nations. The basic rationale for this concept is the fact that coastal fishery resources are still very large and many neighboring countries are unable to utilize them, thus creating the possibility for foreign surplus fisheries. In this situation, the main economic factor that will determine whether or not a long-range fleet will be sent to the coastal zone of other nations will be the harvesting costs increased by poundage and license fees.

If a coastal nation's policy is focused on applying poundage and license fees at nonprohibitive levels, then the problem of proper fee criteria becomes most important. In the U.S. the ex-vessel prices of fish are utilized for computing poundage fees for foreign vessels. In long-range fisheries, the ex-vessel price differs greatly from the value of round fish delivered by inshore vessels employed in coastal fisheries. The ex-vessel price of fish delivered by long-range vessels to the home port is comprised of the harvesting, processing, preserving, and transportation costs and its level could be a few times higher than in traditional coastal operations. In distant-water fisheries, each fishing vessel is charged with the costs of services rendered by the support fleet. These costs greatly increase the final economic result of operation and the price of fish products delivered to the home port. Taking into consideration other cost factors in the complex nature of distant-water fishing activities (for example, different fishing vessels employed in harvesting the same species as well as a variety of processing operations involved), it is very difficult to arrive at a precise final ex-vessel price of a given fishery resource allocated for the foreign nation. If the coastal state is willing to fix its license fee on the foreign ex-vessel price basis, it will be forced to develop extended cost-benefit studies in order to decide the proper point when this price can be determined. When establishing the license fee level, other external factors (such as world tendencies in ex-vessel prices for similar or substitute species and fisheries) must also be taken into account. Distant-water fleets might relinquish surplus coastal resources if they could find alternative and less expensive fishing opportunities in other coastal zones. Local ex-vessel prices of the coastal state could also serve as a starting point for establishing a final price list for foreign fleets, but this alternative would not necessarily express the demand for a given resource in a foreign consumption market. In this case, internal market prices of the distant-water fishing nations could be taken into consideration, although they also frequently do not reflect the real production costs and demand. Many foreign fishing fleets are heavily subsidized and market prices are artificially low in these states.

The readiness of foreign states to pay poundage and license fees largely depends upon the following:

Impact of these fees on the final cost of getting a unit of fish raw material in coastal fishing ground;

Availability of hard currency and dimensions of surplus fishing capacity facing unemployment alternative;

The possibility to utilize existing long-range potential (joint ventures, new fishing grounds on still unrestricted ocean areas, etc.).

Nations without such alternatives may even be forced to accept clearly adverse economic effects of their license fisheries to keep their fish production at desired level or to assure continued employment for their factory-trawlers and fishermen. Increasing costs of coastal zone fisheries for foreign fleets will undoubtedly promote the rise in price for fish food products in the world market. This change can make it possible for coastal fishermen of many nations to engage in fisheries that until now have been uneconomical for them because of low market prices. On the other hand, some distant-water fishing nations might not be able to afford the hard currency outlays for importation of fish food products formerly produced by their own fishing effort.

The new management regime in the coastal zone will entail some drastic revisions in fishing operation policies of the foreign nations. With shortened fishing seasons fixed by the coastal state, only foreign vessels of high catching and processing capacities will be employed because the owner will be forced to take its quota during proportionally much shorter time than before. Limitations related to the by-catch volume will force these vessels to utilize highly selective fishing gear. Fishing area restrictions will necessitate that the foreign vessels be equipped with more accurate navigational

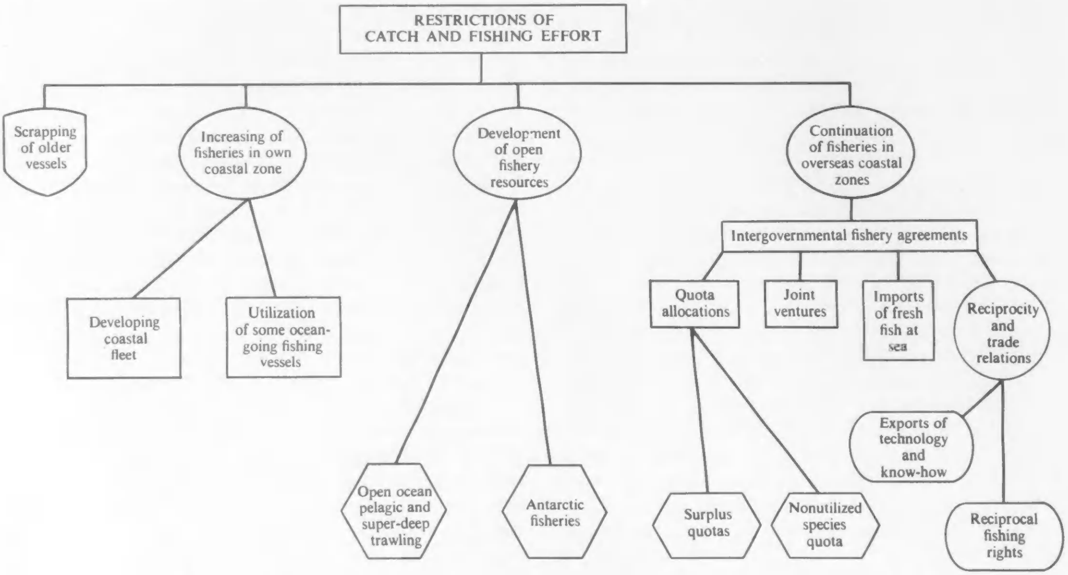
RESTRICTIONS OF CATCH AND FISHING EFFORT
Scrapping of older vessels
Increasing of fisheries in own coastal zone
Development of open fishery resources
Continuation of fisheries in overseas coastal zones
Developing coastal fleet
Utilization of some ocean-going fishing vessels
Intergovernmental fishery agreements
Quota allocations
Joint ventures
Imports of fresh fish at sea
Reciprocity and trade relations
Exports of technology and know-how
Open ocean pelagic and super-deep trawling
Antarctic fisheries
Surplus quotas
Nonutilized species quota
Reciprocal fishing rights

FIG. 1. Alternatives of long-range operators facing restrictions of coastal states.

devices. The desire for maximum utilization of the fishing season to ensure harvesting of all allocated quota will create the incentive for better coordination of catching and support activities in coastal zone fisheries. This will lead to further centralization of foreign fleets management: one disposition center in foreign base port will manage operation of long-range fleets both in terms of fishing and auxiliary activities. Quota fisheries involve many operational elements of the distant-water fleet that are to be known a priori. Volume of catch, species to be taken, area of operation, length of fishing season, number and type of fishing vessels allowed to be employed in these fisheries, and the number and type of auxiliary ships will permit utilization of computer techniques and mathematical programming of disposable fleets. This will result in much better harvests than comparable quantities and type of fish raw material harvested during unrestricted and frequently overcapitalized long-range fishing operations. On the other hand, long-term uncertainty of foreign operators about the coastal state allocation policy makes impossible any realistic development plans for these fleets.

The development of long-range industrial fisheries, which will involve long investment periods, requires that decisions related to their future utilization be made now both by their owners and by the coastal nation. Uncertainty regarding future restrictions and conditions of foreign fishing operations in coastal zones, and insufficient knowledge of the still unrestricted open ocean resources are the main factors that hamper the decision-making process in the expansion programs of many distant-water fishing fleets. This is the reason why the above-mentioned questions still remain unanswered by the foreign fleet operators.

Alternative Opportunities for Foreign Fleet Operators Facing Catch Restrictions

Foreign fleets facing catch restrictions imposed on them by the coastal states will look for many alternative ways of attenuating the negative impact of these changes. The main opportunities available for continued operations after catch limitations have been implemented by coastal nations are shown in Fig. 1. The foreign fleet operators first of all may try to increase the catch in their own coastal waters as mentioned earlier. Because some ocean-going vessels originally designed for overseas coastal fisheries can not be utilized partially or fully in these fishing grounds, foreign operators that are not restricted elsewhere will also be interested in developing these resources. Open ocean pelagic fisheries could be potentially large but the costs of such operations seem to be presently prohibitive for many, even highly developed, fishing nations. Economic and technological constraints place the prospect of open ocean pelagic or super-deepwater trawling (up to 3 000 m) in the distant rather than the immediate future. Only Antarctic operations may absorb larger fishing effort right now provided that the largest and most modern vessels will be utilized in that remote and hydrometeorologically difficult area of operation. Antarctic fisheries, however, are still in the beginning stage of development and, due to many unresolved technological difficulties, can not yet be considered a full-scale and commercially attractive alternative for international fleets.

As a result of the above-mentioned problems, fishing grounds located offshore from the coasts of other nations are still considered an important option for the distant-water fishing activities. In virtually all of the main areas of operation of these fleets, the coastal state's jurisdiction over extended fishery zones has usually been respected by foreigners. Distant-water operators have applied for an allocation of quota to be taken within coastal zones of the neighboring nations.

Two basic groups of the coastal resources are taken into consideration when planning future quota fisheries:

a) Utilization of the part of the fishery resources that is harvested partially by the coastal fishermen. Foreign fleets are thus sharing such a coastal resource and the management decisions of the coastal state must specifically address shared resource utilization and protection aspects relevant both to foreign and domestic fishermen operations.

b) Harvesting of resources not utilized by the coastal country, which is not interested or unable to utilize them for economic, technological, or other reasons. Foreign fleet expect that they will be allowed to take these resources in larger scale and on more liberal allocation criteria used by the coastal state.

Joint ventures with coastal states, although temporary, are potentially promisory solutions, which can generate additional employment opportunities for long-range vessels displaced from their traditional areas of operation. It is also expected that joint utilization of the coastal fishery resources may produce additional fish food supplies to the foreign partner's consumption markets. In absence of joint venture opportunities, foreign operators are frequently forced to buy fresh fish from coastal fishermen. They supply fresh fish to the factory trawlers or factory-mother ships sent to the coastal zone of other nations by foreign long-range fleet operators. This solution is, however, less attractive as it involves high value hard currency outlays for foreign fleets. For some species of high demand in foreign markets, local fishermen can get at-sea-ex-vessel prices, which are much higher than those offered by domestic land processors.[3]

In dealing with developing coastal nations, foreign countries are offering technology transfer and supplies of goods and services in exchange for hard currency and/or access to the fishery resource of coastal states.

Utilization of Surplus Fishery Resources by Foreign Fleets: The Case of North Pacific Fisheries

The most important effect of the 200-mile economic zone, implemented particularly by the United States, Canada, and Soviet Union to their fishing areas in the North Pacific Ocean, has been the introduction of catch volume and fishing effort limitations for foreign operators. In harvesting activities, the distant-water fleets were restricted to national quotas assigned by coastal states. These quotas, being much lower than originally requested by foreign nations, should be taken within a limited time, area, and by a greatly reduced number of vessels. The quota allocation system of the U.S. permits the long-range fleets to utilize only a part of their up-to-date fishing capacity. Practically all foreign distant-water fishing nations have experienced an immediate impact of those limitations.

Under the terms of the U.S. Fishery Conservation and Management Act, the USSR Northeast Pacific catch for 1977 was limited to 480 800 t. The Soviet allocation figure represents a 17% reduction from the 1976 catch level and a 21% reduction from that in 1975. In terms of quantity, these reductions equal 101 800 t and 130 900 t, respectively (Marine Fisheries Review 1977). Quotas for almost all species harvested traditionally in the USSR coastal waters by Japan were far below former levels of Japanese catch (Table 5).

The catch quota accepted by the Soviet Union for Alaska pollock, the species that is regarded as one of the most important for the Japanese fishing industry, was set for Japan at 345 000 t which, though considerably higher than the initial Soviet proposal of 260 000 t, fell short of one third of the 1 073 000 t caught by Japan in 1976 and far short of the total expected catches of about 600 000 t for 1977 (NOAA, NMFS, 1978). In the future the Japanese quota will be gradually reduced.

The foreign quota established by the United States for Poland, both in Atlantic and Pacific coastal waters, could be taken with about one fourth of the fishing potential used by this country during the freedom of fisheries era (Wisniewski 1977).

Some North Pacific distant-water fishing fleets lost practically all of their harvesting opportunities in these fishing grounds which were included in the extended

TABLE 5. Japanese catch in the USSR coastal waters (in metric tons. (Foreign Fishery Information Release NOAA, National Marine Fisheries Service 1978.)

Year	Catch
1974	1 630 000
1975	1 396 000
1976	NA
1977 (estimated)	1 100 000
1978 (quota)	850 000

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[3] In 1975 Canadian fishermen supplied herring to land-based fish meal processors at $35/t. In 1976 Poland bought 15 000 t of fresh herring supplied at sea to factory-trawlers. The ex-vessel price for Canadians was $110/t. In 1978 Polish factory ships purchased 5000 t of this species from Canadian Bay of Fundy fishermen paying $225/t (Pesca 1978).

TABLE 6. Volume of catch and national quotas for foreign Northeast Pacific fisheries (in thousand metric tons).

			U.S. quota allocations	
Country	1975	1976	1977	1978
Japan	1 113 800[a]	1 140 200	1 168 400	1 148 600[a]
Soviet Union	611 700[b]	582 600[b]	480 800[b]	402 100[a]
South Korea	3 300	116 200	81 200[b]	31 200[a]
Poland	58 400[c]	31 900[c]	27 200[b]	23 200[a]
Taiwan	—	NA	5 200[b]	5 800[a]
Bulgaria	NA	NA	—	—
German Democratic Republic	12 200[d]	NA	—	—
Mexico	—	—	—	66 100
Total	1 799 400	1 870 900	1 762 800	1 737 000

[a] State Department telegram to U.S. embassies in Tokyo, Moscow, Warsaw, Seoul, Taipei, and Mexico, November 30, 1977.

[b] Marine Fisheries Review; NOAA; NMFS, Vol. 39, No. 8, August 1977.

[c] Polish Maritime News, No. 266, June 1977, p. 18.

[d] FAO Yearbook of Fishery Statistics, No. 40, 1975, Rome 1976.

economic zones of coastal states. For example, South Korea lost practically all possibilities of harvesting resources in the Pacific coastal waters of the USSR. Consequently, the pressure on the Northeast Pacific fishery resources by Japan, South Korea, and other countries largely increased. Principally for political reasons and historical rights it can be expected that Japan will be allowed to continue its catches within the U.S. and Canadian zones with relatively high quotas. Taiwan and particularly South Korea may largely increase their catch volumes in the U.S. economic zone, although their harvest in 1977 was lower than that during 1976 in this zone. In the future, if the U.S. wishes to increase the quota for Japan, South Korea, and Taiwan and allows the present total allowable catch (TAC) level for foreign fleets to remain unchanged, the expansion possibilities for the Eastern distant-water fleets in the Northeast Pacific will be seriously hampered.

National quotas allocated for long-range fleets for 1978 in the economic zone of the U.S. (Table 6) confirm the extremely selective allocation policy for foreign fleets. Japan's quota decreased only 2% in that year, while South Korea received an additional 10 000 t of Alaska pollock after "additional study of circumstances surrounding *de facto* Korean exclusion from the Soviet zone."[4] Taiwan received a slightly increased quota and Mexico was accepted as a newcomer to the U.S. Northeast Pacific fishing grounds with 66 000 t for 1978.

This volume constitutes 100% of what Mexico required from the U.S. for its long-range fleet during 1978.[5] This is clearly a case where special consideration was given to this adjacent coastal state in allocation of U.S. fishery resources. All these additional increments in the share of the U.S. surplus resources resulted in a reduction of allocation to the USSR (16%) and Poland (15%) in the same year, despite the fact that both countries are contributing lately to the scientific knowledge of the U.S. coastal resources.[6]

With gradually lowering foreign TAC, allocation problems could become extremely sensitive because the coastal states of the North Pacific Ocean deal with resource users with a high catching potential and with an increasing demand for fish. Foreign fleets may thus compete for a higher quota and look for all the possible ways to receive better treatment from the coastal nation. In seeking employment opportunities for their long-range vessels, some states might be interested in engaging them in joint operation with partners who have better access to another nation's surplus quotas. However, it will probably be impossible for overseas countries to affect the transfer of foreign fishing opportunities from one nation to another, when the latter is not formally permitted to harvest or receive fish in the fishery conservation zone off the Northeast Pacific coasts (Pacific Fishery Management Council 1977).

The most important assets of Eastern distant-water states are their bilateral agreements with the U.S. and Canadian governments. These agreements, although they impose numerous limitations on long-range fleets, assure their further presence in the Northeast Pacific coastal waters. Whether or not these fleets will be able to freely utilize the fishery resources of the open waters (not including anadromous species) of the Northeast Pacific Ocean which migrate out of the 200-mile economic zone of the coastal states is an open question.

In the North Pacific Ocean, saury, lantern fishes, rattails, and other fish species can also be harvested in areas outside of the 200-mile economic zones of the coastal states. Saury fisheries, for example, are already developing in the Soviet Union and in Japan in the West Pacific. It is possible that in the future these activities will shift to the Northeast Pacific Ocean (The Pacific Ocean 1967).

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[4] As formulated by the telegram from the State Department to the U.S. embassies, November 20, 1977.

[5] Total quota required by Mexico for Gulf of Alaska was 66 200 t, while for the Northwest Atlantic it was 10 000 t.

[6] For example, the Polish research vessel R.V. *Professor Siedlecki* was developed in 1977 during 3-mo cooperative research activities in the Northeast Pacific coastal waters of the U.S. and Canada.

All of these circumstances will force some coastal states to take special steps for the protection of their coastal resources in the open sea, or to sign separate agreements with potential foreign users. Meanwhile, some of these resources might be considered potential targets by distant-water fishing fleets. Based on the experience of the tuna fisheries, it seems probable that such activities could be developed but their impact on the fisheries of the coastal states, in whose waters these resources spend at least one part of their life cycle, will certainly be greater than before.

Concluding Remarks

There are only a few distant-water fishing nations whose share in the world-long-range harvesting activities is clearly superior. These are the Soviet Union, Japan, Spain, Poland, and some other countries that are highly dependent on the fishery resources actually incorporated within the 200-mile economic zone. As a result, foreign fleets are forced to accept numerous limitations in their fishing activities including large shifts in the composition of the fishing fleet potential. Some long-range fleets will also have to withdraw numerous fishing vessels, particularly older ones, and to replace them with modern, more efficient vessels ready to be used in any fishing area and for any fishing activities. It is, however, hard to expect that these fleets will be able to find immediately full alternative harvesting opportunities. Open sea resources are still being explored insufficiently, while joint ventures in which surplus fishing potential could be employed are expanding very slowly and are mostly feasible in developing nations disposing with rather less attractive fishery resources off their coasts.

The peculiarity and complexity of the long-range operations make the management of these fleets difficult, both for foreign operator and for coastal states. High operation costs, variety of species harvested and processed on board, utilization of support vessels, and subsidy policies of the flag states require that an economic evaluation of the long-range fisheries include short and long perspective effects as well as direct and indirect impact on the national economy. Similarly, the coastal state will be forced to watch more closely these fleets' operation patterns and their economic performance both for rational computation of license fees as well as for the economic impact evaluation of possible joint ventures and other cooperative activities in fisheries with foreign operators. When future opportunities of distant-water fishing fleets are analyzed, the political factors will play a much more important role in this field than before. Foreign fleets expect that many nations, particularly developing and some developed like the U.S., Canada, Australia, or New Zealand, will not be at least temporarily capable of or interested in full utilization of some coastal resources, thus creating the existence of a surplus on a yearly basis. As long as many distant-water fishing nations will consider overseas fishery resources an important source of their animal protein supplies, the pressure on the coastal zone fish stocks will be high in the future. This can raise the license fees levels and contribute to growing complexity of the coastal zone regulations.

In the North Pacific Ocean, where restrictions imposed by coastal states contributed to the reduction of harvesting opportunities for long-range fleets, operating mainly in the Soviet and U.S. coastal zones, the volume of catch taken by foreigners is still the highest in the world. However, all long-range fishing nations had to reduce their fishing effort and entered a period of considerable difficulty in full utilization of their highly developed catching potential. This, coupled with coastal states' area and season limitations, has even led to only partial utilization of some national quotas in the U.S. coastal zone during 1977. In the Bering Sea and in the Gulf of Alaska, the Soviet fleet took only about 50% of its yearly quota, Taiwan 27%, and Poland barely 20% (National Marine Fisheries Service Report 1978).

Because of the great potential of the fishery resources in the North Pacific and the fact that they are shared by the highest developed fishing countries which belong to different political and economic systems, the management of foreign fleet operations by coastal states becomes a highly sensitive and complex task in this region.

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Rational Fishery Management in a Depressed Region: the Atlantic Groundfishery[1]

W. C. MacKenzie

Department of Fisheries and Oceans, Fisheries Prices Support Board, Ottawa, Ont. K1A 0E6

MacKenzie, W. C. 1979. Rational fishery management in a depressed region: the Atlantic groundfishery. J. Fish. Res. Board Can. 36: 811–826.

The economic and social milieu of the commercial fisheries in the Atlantic provinces of Canada is described, followed by an analysis of the structure of the major sector, the fishery based on the demersal stocks of the region. Existence of the classic features of mature fisheries, i.e. congestion and economic distress, is established for this fishery and the causes considered. Extended national jurisdiction over the use of fishery resources, it is argued, while it improves opportunity for development, does not affect those causes. Possible approaches to rational management of the fishery are reviewed, in particular the institution of inducements for fishing enterprises to minimize production costs. A discussion in this respect of quasi property rights for resource users and associated problems concludes the paper.

Key words: economic depression, congested fisheries, regional development, Atlantic provinces, groundfish(demersal) resources, industrial structure, fishery management, rationalization, quasi property rights.

MacKenzie, W. C. 1979. Rational fishery management in a depressed region: the Atlantic groundfishery. J. Fish. Res. Board Can. 36: 811–826.

Après avoir décrit le milieu économique et social des pêches commerciales dans les provinces atlantiques du Canada, nous analysons la structure du principal secteur: la pêcherie fondée sur les stocks démersaux de la région. Nous démontrons pour cette pêcherie l'existence des caractères classiques de pêcheries matures, i.e. congestion et détresse économique, et nous en examinons les causes. Nous arguons qu'une juridiction nationale élargie sur l'utilisation des ressources halieutiques, tout en améliorant les chances d'expansion, n'affecte pas ces causes. Nous passons en revue les approches possibles à une gestion rationnelle de la pêcherie, en particulier l'établissement de stimulants pour encourager les entreprises de pêche à minimiser les coûts de production. Nous terminons cet article par une discussion de droits de quasi-propriété pour les utilisateurs de la ressource et des problèmes qui s'y rattachent.

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The Socioeconomic Setting

If it is accepted on theoretical grounds that under conditions of open access the tendency to overcrowding and depression is universal and inexorable, it follows that this is the context in which virtually all programs of fishery rationalization are likely to be applied. The opportunity for application in a "virgin" fishery is rare. The latter type of fishery, moreover, tends to be supplementary to long-established or mature fisheries. For enterprises in the fisheries of the Atlantic coast, for example, as will be shown later, fishing is often a quite diversified activity. Expansion into new fisheries, that is, the utilization of hitherto neglected species or stocks, usually takes place from a base in fisheries that are densely congested and often severely depressed. Rational management of the new fishery by itself, therefore, would have little effect in mitigating the general congestion and depression.

The proposition that Canada's Atlantic fisheries are economically depressed is hardly in dispute. It is supported by empirical evidence — fragmentary and sometimes ambiguous, but substantial enough. As recently as 1976, according to estimate, net annual earnings from fishing averaged slightly less than \$3500 per participant. On a man-year basis, i.e. taking account of the widespread seasonality of fishing in the region, net earnings on the average are slightly more than \$6500. The regional averages are inflated by the relatively high level of earnings in Nova Scotia. The averages for the other provinces are well below those for the region as a whole. Average net earning per man-year in fisheries are significantly lower than the level found in comparable industrial sectors, varying from province to province between 20 and 75% of average annual wages for the same year in logging, mining, and construction.

These data suggest an apparently serious state of depression. The appearance is relieved somewhat when

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account is taken of varying degrees of attachment to commercial fishing as an occupation. Less than 60% of the fishermen in the region (22 900 out of a total of 39 700 in 1972) claim fishing as their main source of income. Furthermore, only about 15% of this number earn more than half their total income directly from fishing, i.e. a tiny minority (just under 10%) of all participants in the fisheries. Again, the proportions vary from place to place, direct dependence on fishing as the major income source being highest (approximately 25% of participants) in Nova Scotia.

An explanation of the anomaly, i.e. the evidently exaggerated claim to dependence on fishing for a livelihood, may lie in the fishermen's attitude to unemployment "insurance." Through fishing (plus odd-jobbing), fishermen earn entitlement to UI benefit payments in the winter off-season. These provide a cash flow during the 5 mo or more when fishing operations are suspended in the Gulf of St. Lawrence and on the eastern coast of Newfoundland. For 70% of claimants, on the average, i.e. those in the lower income brackets,[2] annual UI benefits exceed 50% of gross earnings from fishing. For half[3] the number in this gorup, UI benefits equal gross earnings from fishing. Total income in the latter case typically is divided evenly between (a) fishing, (b) UI benefit payments, and (c) other sources. Since entitlement to benefit is earned in the main from fishing, benefit payments are interpreted as fishing income!

Although not more than half of all participants in the Atlantic fisheries qualify for UI coverage on the basis of that occupation, the benefit payments they receive provide in the aggregate a massive income increment, approximately $40.0 million, net of contributions, in 1977–78. This represents an additional 20–25% to net returns during 1977 in the primary fishing industry of the region as a whole. Interprovincially, the ratio varied from 15 to 45%. For the group immediately concerned, the enhancement of income would be on a much larger scale. For many, perhaps the majority, in this group the UI program has become in effect a form of annual income supplementation — a clumsy form, since entitlement is based on sales of fish, but (because token contributions are made to the program) a "respectable" one. Since 1976, when regionally extended benefits (in areas of higher-than-average unemployment rate) were made available to self-employed fishermen and their crews, the program has been less regressive in impact than formerly.

The evidence educed above to demonstrate the diversification of income sources among fishermen of the Atlantic region, while indicating that the impact of depression in the fisheries on the individuals and households involved may not be as severe as the data on fishery earnings alone would suggest, serves, nevertheless, to confirm the existence of a depressed and overcrowded fishery sector in a depressed regional economy. The evolvement of a widespread dependence on a variety of sources for livelihood is readily explicable in this instance. Seasonal restrictions on fishing activity have already been referred to. The traditional fishing enterprise required extensive space ashore (for curing catches) and, as the more advantageously situated communities became congested, operations were extended to progressively more remote locations. The existing configuration of settlement of the regional fishing population may thus be accounted for.

In locationally disadvantaged areas, from an early stage, fishing has been combined with other occupations, e.g. logging, trapping, and the like, in the off season. A more fundamental cause of the diversification found today, however, is an institutional one, i.e. open access to the use of common-property resources. Specialization by fishing enterprises in major fisheries, e.g. cod or lobster, is not inconceivable, given controlled entry. In the absence of such control, the reduction in catch rates, resulting from an influx of additional enterprises, forces all to diversify, i.e. to move into other fisheries. Ultimately, with continued fleet expansion, even combination fishing enterprises are unable to provide an adequate source of income for their dependents and the latter are forced to seek supplementary employment outside the fisheries. This seems to have been the trend or pattern of development historically in the Atlantic provinces. The trend may have been intensified in some areas by subsidization of small-scale enterprises in long-since overcrowded fisheries, which tended to reduce viability all around.

The diversification just described complicates enormously issues of entry control and access allocation in the fisheries. Although the necessity for such allocation and control is not in doubt, the existence and extent of congestion or overcrowding in the fisheries is more difficult to assess than is the fact of depression. Overcrowding is defined as excessive capacity (in relation, with a given technology, to resource availability) resulting not simply from the multiplication of participating enterprises, but from augmentation of their fishing power as well. Proof of its existence — apart from actual interference among craft and gear on the fishing grounds — takes the form of falling catch rates, capital losses, and related signs of industrial debility, the sort of development that traditionally has evoked regulatory measures to reduce fleet efficiency!

The evidence that, as a general proposition, overcrowding is present in the Atlantic fisheries is largely circumstantial. Over the past decade or so, while the value of primary production (in current terms) increased by approximately 185%, the value of fishing craft increased by roughly 365%, i.e. about twice as fast. Unfortunately, data on the value of fleet units reflect not only new investment during the period, but also the inflation of market prices for existing vessels.

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[2] Filers reporting up to $5500 gross income from all sources in 1972.

[3] Filers reporting total income of $3500 or less in 1972.

Nevertheless, the presence of capacity in excess (in some instances, grossly in excess) of requirements for economically viable operation is attested by evidence from particular fisheries, including the groundfishery to which attention is now directed.

The Atlantic Groundfishery

STRUCTURE

The groundfishery is the major fishery of the Atlantic region, employing (on a full- or part-time basis) 55% of fishermen and accounting for 40% of primary production — 45% of the value of products marketed. Many fishing enterprises, particularly those engaged in offshore operations, i.e. using fishing craft over 150 GRT (gross registered tonnage) in size, specialize in this fishery. Most full-time fishermen are employed in these enterprises. Small-scale or inshore enterprises, i.e. those using craft under 25 GRT (by far the most numerous), and enterprises using an intermediate technology, if specialized at all, tend to specialize in other fisheries, e.g. lobstering, and herring or scallop fishing, respectively. There are exceptions, notably in the case of the Newfoundland trap fishery for cod, which is about as highly specialized as it is possible to be.

In general, however, diversification is the rule in the Atlantic fisheries. Of greater importance than combinations of groundfishing with fishing for pelagic and/or crustacean species, and, therefore, more apposite to the present discussion, is the extreme heterogeneity of the groundfishery internally. The diversity of enterprises, e.g. regarding type and size of fishing craft and, consequently, the level of investment involved, has been referred to. Related to this is an institutional dichotomy. The larger offshore draggers (side- and stern-trawlers) are owned and operated by vertically integrated processing and trading companies. The small and middle-sized craft, i.e. trap tenders, gillnetters, longliners, seiners, and draggers, are owned and operated by independent fishermen.

The small-scale or inshore fleet (comprising craft under 25 GRT) accounts for about one third of groundfish production overall. The division between the two other fleet components, i.e. the intermediate or nearshore fleet (comprising craft between 25 and 150 GRT) and the large-scale or offshore fleet (comprising craft of 150 GRT and over), is not reported in sources available as this is being written, nor is the number of vessels in each of the three categories. The last-mentioned group, the company-owned fleet component, comprises about 300 vessels, and it is likely that it obtains by far the larger share of the offshore catch. The classification of fishing craft as "inshore," "nearshore," and "offshore," while useful for certain purposes, perverts reality in some respects. The essential feature associated with size variation is that mobility and fishing power generally increase with craft size. This central tendency, however, is distorted and overridden by other factors, e.g. proximity to fishing grounds, constraints imposed by climate, customary or traditional practices, and entrepreneurial agressiveness. So-called nearshore and even inshore boats operate side by side with offshore vessels on Georges Bank, for example. The offshore fleet is based on not more than 20–25 ports but, of course, is comparatively footloose at sea. The nearshore fleet operates from several shore bases and the inshore fleet from close to a thousand. Offshore vessels fish for 230–235 d/yr; the smaller craft, even those operating throughout the year, fish for somewhat less than half that time.

Added to the diversity of enterprise and equipment is the broad range of stocks exploited. Some 35 groundfish (demersal) species of commercial use are found in northwestern Atlantic waters. At least 15 species are caught by the Canadian fleets in directed fishing operations — up to 10 or a dozen by a single enterprise in the course of a year's fishing. The relative importance of the several species varies widely in accordance with location and class of enterprise (size of vessel and type of gear used). Cod is the mainstay of the small-scale (inshore) enterprises, especially in Quebec and Newfoundland — in these provinces, the small-boat groundfishery becomes virtually a fishery for cod. In New Brunswick and Prince Edward Island, flounders and plaice, and, in Nova Scotia, haddock and pollock, are important adjuncts to cod in the mix of species utilized by the inshore sector. Versatility is related to mobility and power and it increases with size of craft. Nearshore craft in Nova Scotia make extensive use of haddock and pollock, for example, and those in Newfoundland supplement cod with turbot. Most versatile of all are the largest craft (all based on ports in Nova Scotia and Newfoundland) which, in addition to utilizing all the species already mentioned, monopolize the catch of redfish (a deep-water species).

Because of its heterogeneous character, it could be argued that the Atlantic groundfishery is not a definable fishery at all but a collection of quite divergent elements. A measure of unity among these elements is exerted by (a) their dependence on common natural resources and (b) their service of common markets where the products of the fishery are subject in varying degrees to substitution of one for another. There are broadly two product markets: one for fresh (chilled) and frozen products, restricted more or less exclusively to North America and dominated by the U.S. import trade, and one for cured (saltfish) products, located chiefly in Caribbean and Mediterranean countries. The former market admits products derived from the whole range of groundfish species, the latter demands codfish principally. Chilled and frozen groundfish is produced throughout the Atlantic region, excepting the remotest areas, while cured fish production is now restricted to the Gaspé, western Nova Scotia, and parts of Newfoundland. Cured fish production has been in decline for many years, for reasons not particularly relevent here, and now represents somewhat less than 20% (in quantity terms) of total groundfish production in the region. It is likely to experience a revival, however, especially in Newfoundland, with recovery of the cod resource.

Data indicative of depression are not available for the groundfishery separately but use can be made of certain indirect indicators. Production, which peaked in 1968 with a nominal catch of approximately 630 000 t, dropped rapidly to 420 000 t in 1974 and 1975. At that point, the fishery and the industry and trade based on it were rescued from dissolution (and, possibly, from rationalization) by an infusion of aid (amounting in total to something like $150.0 million) from the federal government. The crisis was triggered by sagging prices for groundfish products in the U.S. market, the effect of which was compounded by rising energy and labor costs and perpetually falling catch rates. Average operating costs in the offshore fleet had doubled (from 6 to 12¢/lb of fish as landed) between 1968 and 1974 and, presumably, the fleets of smaller craft experienced a similar worsening of their situation.

The industry responded to the continuous decline in the availability of cod after 1968 (that of haddock had been in decline since 1956) by intensifying fisheries for other groundfish species — the catch of flounders and plaice reached a peak in 1970 and those of redfish and pollock in 1973. This was a period of rising prices and, despite declining volumes, the value of groundfish production continued to rise (by nearly 65% over the 5 yr). Information on the growth of investment in the fishery is lacking but it is not without significance that the increase in value of fishing craft generally was greatest in Newfoundland, where the groundfishery is dominant. A substantial expansion of processing capacity is known to have taken place also during the period.

On the other hand, excepting Quebec but including Newfoundland, the number of participants in the Atlantic groundfishery continued to decline. This reflects a withdrawal of small-boat (under 10 GRT) enterprises from the fisheries in areas such as the eastern coast of Newfoundland where depletion of stocks offshore in the international fishery drastically reduced the availability of fish inshore. It is unlikely to be coincidental that between 1968 and 1973 the numbers of craft in that size class and the number of fishermen in the groundfishery of the region both decreased at exactly the same rate, i.e. 18%. Since the groundfish catch decreased by one third over the period, however, this exodus of small-scale enterprises could have had little if any perceptable effect in an overcrowded fishery.

Although the groundfish catch in total has shown long swings over time, rising fairly consistently until 1968 and falling thereafter, as has been noted, year-to-year variation has been slight, averaging about 10%, in contrast with the Pacific salmon fishery, for example, in which the average variation is at least 30%. Relatively mild fluctuation is also characteristic of the fisheries for cod and some other groundfish species separately. Variation increases in amplitude, of course, for particular areas and, for fishing enterprises individually, it may be very wide. Instability, where it exists, is associated with the technology in use — the more advanced the technology, other things being equal, the greater the degree of mobility and versatility, in relation to length of season and territorial range of operation, grounds fished, and species utilized. The increase in stock densities, resulting from restoration of the natural resource in the direction of its pristine state, would contribute to the further stabilization of catches for all classes of craft and gear but would not remove the advantage in this respect inherent in relative mobility.

DEVELOPMENTAL PROSPECTS

Recovery began in 1975 and is continuing. Ultimate catch levels are not necessarily limited to those achieved in 1968, since it is anticipated that the Canadian fleets will be capable of taking a larger share of the total catch from the grounds under extended national jurisdiction. Total allowable catches from these grounds are projected to reach 1.2 million t in the aggregate by 1985 and perhaps earlier. This would permit the 1968 catch total being doubled. On closer examination, however, the outlook is not quite so rosy. In the Gulf of St. Lawrence, for example, the total permissable catch would be about four fifths of what it was in 1968 and that for redfish separately would be a small fraction of what it was in that year. The prospect for stocks on the Scotian Shelf is not a great deal better. TACs are 80% higher overall than the catches actually taken in 1968 but slightly more than half the total consists of hake and "other" species that the Canadian industry hitherto has found little or no use for. With reference to conventional species, the TACs for cod and haddock would be half the catch levels of 1968, that for flatfishes, i.e. flounders and plaice combined, would be roughly equal to the 1968 catch level and those for pollock and redfish would permit catch increases of 100 and 280%, respectively, above the 1968 levels. The latter together, unhappily, are only 20% of the aggregate TAC for these grounds.

Prospects for the stocks located on grounds to the southeast, east, and northeast of Newfoundland (designated, in brief, the Grank Bank and Northern Grounds) are considerably more optimistic. Compared with the levels of 1968, the projected TACs for these stocks would permit an 85% increase in the catch of flatfishes (including turbot) and a twelvefold increase in that of redfish. In the latter case, however, the increase over the current catch level would be relatively modest. On the whole, the major improvement in outlook for the entire region in this period is represented by the projected TAC for cod in this area, especially the northern cod stock, i.e. the stock or stocks of the

Hamilton Bank and adjacent grounds. Potentially, it would permit an annual catch at least 4 times the current level and 175% higher than that of 1968. Since these grounds already yield approximately half the total regional catch of cod, it would appear that the latter catch could be doubled.

It is probably not as simple as that. Traditionally the Canadian share of the catch from the stock (stocks) involved has been taken inshore, chiefly by the trap fishery, along the eastern stretches of the Newfoundland–Labrador coast. The fishery is based on a feeding concentration in midsummer and is of very short duration, about 2 mo maximum. If the inshore migration includes 60% of the stock(s), as has been estimated, it might be impossible to accommodate that proportion of the annual TAC in so short a time. The offshore fishery, which is based on spawning concentrations in late winter and early spring, is of somewhat longer duration but operations usually take place in ice-covered water. Distance and inadequate equipment for such operations have prevented a Canadian fleet from participating in this fishery.

Realization of the potential catch of cod from the stock(s) under consideration, therefore, implies the application of innovative technologies in either the inshore or the offshore fisheries or in both. With the aim of displacing foreign fleets, experimentation has been concerned mainly with ice-reinforced freezer–trawlers for the offshore grounds. It would be unfortunate, however, if a bias toward capital-intensive technology were to distort fleet development. In particular, the possibility of an "intermediate" technology (nearshort craft) should not be overlooked, as complementary with and even in part as replacement for the cod trap. The latter produces fish of inferior quality and, because of the extreme peak in landings, generates intractable problems (with attendent costs) in the handling, storing, and processing of codfish. As suggested later, the issues involved here await further study and clarification.

That is not all. Progress toward capturing the entire TAC for northern cod would be constrained by the availability of market outlets for the derived products. It would mean a total regional catch approaching 600 000 t of codfish by 1985, or (depending on mix) possibly 150 000 t in product form. It is probable that less than half of this production could be absorbed by the U.S. market and that the bulk of the remainder would have to be exported, as frozen or cured products, to other (principally European) markets. That would imply at least a quadrupling of the current volume of trade with those markets — conceivable but perhaps unlikely.

The foregoing appraisal, regrettably, provides little justification for the exaggerated notions, currently rife in the Atlantic region, of economic development on the basis of an expanded groundfishery. With an unemployment rate of 15%, and other efforts toward industrial diversification having met with mixed success at best, it is natural and inevitable that such notions should be entertained. Nevertheless, to the extent that policy and the course of events are determined thereby, the implementation of rational fishery-management programs is impeded.

The most inflated expectations relate to expansion of the off-shore fishery. The impression seems to be that, concurrently with phase-out of the foreign fleets, production by the Canadian fishery could expand to that of the international fishery at its peak (2.8 million t of groundfish in 1965). The grounds from which that catch was taken, however, covered a much larger area than the zone of extended national jurisdiction. The latter excludes the grounds west of Greenland (a Danish zone), the Flemish Cap and the "tails" of the Grand Bank to the east (under international control), and Georges Bank and other grounds to the south (in the U.S. zone). Also within it is a subzone under French control. Furthermore, exploitation of the groundfish resources could not be permitted again to reach the intensity it did in the 1960s. At current portmarket prices, even the most successful of existing offshore fishing enterprises would require an additional catch of at least 25%/yr to break even. Only 10 out of some 30 groundfish stocks in the zone are predicted to be capable of yielding an increase in catch rate (CPUE) of that magnitude by 1985. For a few stocks, the rate is expected actually to fall. To ensure fleet viability in the future, it is clear that a high degree of stock density must be achieved and maintained. This implies restriction of TACs to the extent necessary for that purpose.

Expectations are high regarding certain segments of the inshore fishery as well. This is evident, for example, in the case of the Newfoundland trap fishery. Approximately 3000 traps were in operation in 1977 and, following a relatively successful season, an increase of 40% is reported for 1978. The investment needed for entry to this fishery is not great and, in any event, funds for the purpose are usually available from fish buyers competing for a (still) scarce supply of codfish. Evidently, such is the massive quantity of fish in a run, individual trap catches are not affected perceptibly by the number of traps in the water. The number of usable trap berths, however, is limited at any particular location. This, as well as the difficulty of coping with the "glut" of fish from traps, may halt expansion of the fishery. Resistence to the influx of newcomers, regarded as interlopers and "moonlighters," has arisen already as a result of the loss of berths to recent entrants and the consequent curtailment of opportunity for established fishermen.

The issues confronting the institution of rational fishery management in this region are epitomized in the preceding case. Those issues relate to the choice between (a) the generation of employment in the fisheries, (b) the enhancement of fishermen's income, and (c) the appropriation of resource rent by the state. By begging certain questions, e.g. relative to technical feasibility, one may attach some "quantification" to these alternatives.

At present port-market prices, the annual TAC of 400 000 t projected for the northern cod stock(s) in 1985 would have a landed value of $130.0 million. Given restoration of the catch-rate or productivity level of 25 yr ago (averaging 30% over the current level), this TAC could be taken offshore by the equivalent of 500 stern-trawlers of existing capacity, operating for 3 mo and employing 7500 fishermen. Employment for 20 000–25 000 other persons would be generated ashore in the processing plants served by this fleet.[4] Harvest of the TAC in such a manner, assuming a break-even for the 3-mo season at present factor prices, would entail private costs for the trawler enterprises involved of approximately $100.0 million in the aggregate. The potential surplus, i.e. rent, would thus appear to be in the vicinity of $30.0 million/yr in constant terms.

If employment rather than rent maximization were the prior criterion, that proportion of the TAC available in waters close to shore, i.e. presumably 60% of the total, could be reserved for the small-scale fleets. The rent potential from the restricted quota offshore would thereby be reduced to $12.0 million or thereabouts, to which, to the extent that income-enhancement objectives permitted, there might be some addition from small-scale fleet operations.

Reservation of a quota of 240 000 t for the small-scale fleets would necessitate an allocation between the inshore fleet (trapping enterprises, chiefly) and the nearshore fleet (composed of gill-netters, longliners and, perhaps, seiners and draggers). A division of two thirds for the former, based on historical performance, and one third for the latter may be supposed.

Data on the operation of nearshore craft (gill-netters, for the most part) in the area in question are lacking. Experience with the more efficient of similar types of vessel elsewhere in the Atlantic region, however, would suggest that the annual subquota of 80 000 t might be harvested effectively over a 3-mo season (assuming that to be the period of availability) by some 450 (60–65-ft) stern-draggers or 1100 (45–50-ft) longliners. Employment in fleet operations would approximate 1500 and 3800, respectively, for 3 mo.

As landed, the harvest would be valued (with 1977–78 prices) at just over $25.0 million. In comparison, aggregate production costs would approximate $20.0 million for a dragger fleet and $30.0 million for a longliner fleet. At present codfish prices and input costs, therefore, a longliner operation would be uneconomic for this fishery but a dragger fishery would be capable of yielding a surplus in the neighborhood of $5.0 million. Rather than being appropriated as rent, this surplus, which averages slightly more than $10 000 per vessel, might easily be absorbed by augmentation of returns to the participating enterprises.

It is necessary to repeat, perhaps, that the above calculations are based on a number of hazardous assumptions, including (a) the applicability to fishing grounds northeast of Newfoundland of technologies proved successful off southwestern Nova Scotia, for example, and (b) the ability of nearly 500 stern-draggers or over 1000 longliners to find an opportunity for profitable fishing operations, outside the northern grounds under consideration, for as much as 9 mo of the year. To assume, on the other hand, with respect to the last point, that a 3-mo season of fishing the northern cod stock(s) could be turned into a viable operation by itself would be even more rash. With existing input–output relationships, this would require prices for codfish as landed of 50 and 70¢/lb, respectively, for the dragger and longliner enterprises involved.

In the case of the subquota (160 000 t) for the inshore fleet, it is assumed — as a simplification for expository purposes — that the whole of this would be taken by trap-fishing enterprises. On the basis of average productivity levels in the early 1950s, before the decline in cod availability inshore, it may be estimated that 4200 trapping enterprises (coincidently the number of traps said to be in operation in 1978) could be accommodated in this fishery. These would employ a total of roughly 14 000 fishermen for a period of 6 wk, more or less. With landings valued at well over $50.0 million (according to present prices), gross earnings per enterprise would average $12 000 for the season.

Up-to-date information on production costs in the trap fishery are not available to the present writer. Considering (a) the extent of unemployment in the Newfoundland economy, (b) the general state of underemployment in the fisheries of the province, and (c) the type and grade of skills used in trap fishing, one may conclude that the opportunity cost of labor in this fishery, although certainly not zero, is probably quite low.[5] With subsidies and loans (at preferred rates of interest) for the acquisition of equipment, the capital market may fail to ration inputs of this factor. These conditions, in association with costless entry, foster an explosively expansionary tendency in the fishery.

Trap fishing enterprises exist to exploit the inshore run of codfish. Consequently, the issue of their deployment of equipment elsewhere during the off season does not arise. This, however, is not true of the manpower engaged. The net earnings of crew members in 1985 may be estimated as likely being rather under than over $2000/man for a 6-wk season. Like several other fisheries in the Atlantic region, e.g. the lobster fishery in certain locations, prosecution of the codtrap fishery would seem to depend on the ability to recruit a labor force from a pool of relatively mobile fishermen and other workers. Mobile, that is, in the sense of being able and willing to move from fishery to fishery and/or in and out of the fisheries during the course of a year. Among other things, this may carry significant implications with respect to the "professionalization" of fishermen and related issues.

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[4] The employment of the vessels and plants and of the associated labor during the remaining three quarters of the year is left out of the calculation.

[5] The received image of the poor fishermen is to be stood on its head — he is a fishermen because he is poor, not the other way around.

The alternatives explored here, with reference to management of the fishery or fisheries based on the northern cod stock(s), as of 1985, may be recapitulated as follows:

TAC allocation %			Technology applied	Rent generated $ million	Subsidization required $ million	Employment created[a] primary m/y	secondary m/y	total m/y
100			Advanced	30.0		1900	6000	7900
100	40		Advanced	12.0		800	5200	8400–8800
	60	20	Intermediate	(a) 5.0		400		
				(b)	5.0	1000		
		40	Traditional		15.0[b]	1800		

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[a] Time and the availability of data have been insufficient to permit investigation of multiplier effects on employment in industries linked to the fisheries. These are known to be substantial in the case of the primary (harvesting) and secondary (processing) sectors, especially the latter.

[b] This is an arbitrary figure, representing not an overt subsidy but the current (1977–78) level of income supplementation in the form of UI benefits paid to fishermen in Newfoundland. The bulk of these payments are made to claimants in the area affected by recovery of the northern cod stock(s). By making possible improved earnings from fishing, the recovery may reduce the need for such supplementation but, while the fishing season is confined to a few weeks' duration between the beginning of June and the end of September, and employment opportunities outside the fisheries continue to be restricted, the outlay for this purpose (or an equivalent) should not be expected to diminish a great deal.

The writer's intent, in this digression on the northern cod fishery, has been to exhibit, by way of a case study in miniature, the nature of some of the more important problems of fishery management. As a contribution to policy making and planning, it is of necessity highly speculative. The outcome may appear to be disruptive of certain preconceptions, e.g. as to the relationship between capital and labor inputs in the commercial fisheries, but, pending exhaustive analysis and confirmation (or refutation) of these tentative findings, judgement must be suspended.

Conclusion: Approaches to Rationalization

In the foregoing discussion, an attempt was made to describe the situation in which a program or programs of access allocation for the Atlantic groundfishery (groundfisheries) would have to be designed. In so far as information sources would permit, the writer endeavored to establish, within the context of a depressed regional economy, the fact of congestion and depression in this fishery. He sought also to prove that the regime of extended national fishery management, while it might provide greater scope for maneuver in development planning, removes none of the causes of congestion and depression. On the contrary, because it appears in some quarters to open up unlimited expansionary vistas, it may well reinforce those causes.

Against that background, then, the major problems in the design of access-control programs relate to the extraordinary heterogeneity of the groundfishery and the complexity of its linkages or interrelationships with other fisheries and other sectors of the economy. The questions, relevant to this issue, that should have emerged from the discussion include the following:

1. Considering that (a) fishable concentrations of the various species are dispersed in time and space and are normally of short duration and that (b) the existing diversification of activity in fishing enterprises represents an adaptation to these circumstances, should programs of access allocation and input rationalization be designed to optimize diversity?

2. Alternatively, since resource-use management under exclusively national jurisdiction introduces a fundamental change in the institutional environment of the fisheries, might such programs be designed to encourage specialization (a) in fishing as an occupation, i.e. to eliminate dabblers in this sector, and (b) in specific fisheries?

3. Under what conditions would specialization of type (b) be a legitimate object of program planning, and do such conditions obtain in the Atlantic groundfishery or in any parts thereof?

4. Should a program or programs of access and input control be designed to effect an optimal mix of fleet components and, if so, how might that purpose be accomplished?

5. Is a single program for the groundfishery as a whole conceivable and, if so, what would be its essential features?

6. If such a program is inconceivable, how might the fishery be segregated into identifiable management units?

7. How should a program or programs be "delivered," (a) through direct regulation by a management authority or (b) through provision for selfregulation, e.g. by granting property or quasi-property rights in the natural resource(s) to users?

8. How might the latter approach be adopted in the case of the Atlantic groundfishery, i.e. are there discrete stocks or grounds that could be reserved for particular industry groups or organizations?

9. Under a program of this kind, could it be assumed that socially responsible behavior, e.g. protection of consumer interests, on the part of resource proprietors, would be ensured by the market nexus?

10. What provisions regarding tenure, the exchange of access rights among individual proprietors or proprietory groups, organizations, and enterprises must enter into such a program?

11. How might the trade-off points be identified among the several program objectives, e.g. between enhanced personal income and numbers employed in a fishery and between both and returns (rent) to the rest of society (as resource owners)?

12. Since the conditions under which these trade-offs

must be made change through time, to what extent is it possible to incorporate the requisite flexibility in the design of programs?

Flexibility, indeed, must be the cardinal principle of fishery-management policy and programming at this point in time. It is simply not possible to prescribe what the structure of the Atlantic groundfishery should be in 1985, let alone the year 2000, i.e. only 20 yr from now, and this goes for other fisheries as well. Fishery management is still based on deficient models. A predictive capability, with reference to the impact and interaction of economic and social forces in fishery development, is wanting. At the same time, there is mounting pressure from a variety of vested interests for decisions affecting access allocation and industrial structure. In the absence of an adequate knowledge base, including a realistic model of the fishery "system," management authorities are forced to decide ad hoc in these matters. Imminent in this, obviously, is the probability not merely of suboptimization (which might be lived with), but of options for the future being preempted and policy becoming set in a rigid and ultimately ruinous mode.

The basic objectives of management for the groundfishery may be specified as being (a), over the long term, to reduce dependence on the fisheries in general, (b) to avoid the dislocation of fishermen and their communities, (c) to prevent the attraction of additional redundant labor and capital into this fishery, and (d) to motivate the operators of fishing enterprises toward the use of low-cost methods of harvesting. Policy instruments, i.e. strategies and programs, should be designed to move the industry in the directions thus indicated. For the present, these instruments should be neutral, e.g. with respect to the issue posed in questions 1 and 2 above. It is necessary only that policy, e.g. through licensing arrangements, accommodate the range of efficient possibilities between extreme diversification and absolute specialization.

It cannot be emphasized too strongly that the key agent in fishery management is the fishing enterprise, i.e. the locus of decision-making in the primary sector. In the Atlantic groundfishery, enterprises vary enormously from very small-scale (one man) affairs to the fleet divisions of large firms, representing investments of $25.00 million and more. The existing composition of the primary groundfishery manifests its evolvement in the postwar milieu. In response to a growing demand for a stable, year-round, and diversified supply of groundfish products, increasing reliance was placed on the use of offshore (deep-sea) fishing craft. Because of their cost and possibly for operational reasons, the units of this fleet, as indicated earlier, were acquired by the larger processing and trading companies. To a minor extent, this represented a replacement of capacity (chiefly that of the traditional fleet of dory schooners or "salt bankers"). The persistence of restricted employment opportunity throughout the region, however, along with public assistance for construction, stimulated expansion of a nearshore fleet during this period and prevented the inshore fleet from being supplanted on a widespread scale.

While these developments were taking place, the groundfish resources (until 1977, largely the common property of the international community) were coming under intensive harvesting pressure, especially from European fleets which expanded rapidly from 1956 onward. In addition to the acute competition induced by open access, it is possible that the form of technology applied to increase domestic fishing power owes something to emulation of foreign exemplars. In any event, as already demonstrated, the primary sector of the Atlantic groundfishery displays the classic features of a mature fishery: overcrowding and economic distress. The recovery of the past 2 yr has masked these features, but only temporarily.

Identification of what is required for a reversal of the trend that characterizes the maturation of commercial fisheries is a relatively simple matter. The institutional environment must be such as to impel fishing enterprises toward low-cost production, i.e. to economize in the use of inputs. It is in the realization of this concept that difficulties are encountered. An attractive approach prima facie would be to allocate to a producers' organization (corporation, cooperative or the like) exclusive rights to the harvest of a specific resource stock, under some mutually acceptable arrangement, e.g. in return for a royalty on the catch and/or acceptance of responsibility for resource husbandry. There is evidence, however, that to be effective in removing the impetus to destructive competition, the number of enterprises in a grouping of this kind must be quite small. The approach, therefore, might be inapplicable generally in the Atlantic groundfishery, in which the stocks (assuming they can be separately delimited) are often very large. Under the suggested arrangement, consequently, competition among individual enterprises might be replaced by equally malignant competition among collective enterprises and nothing would be gained.

Nevertheless, the practicability of the creation and diffusion of (quantitative) quasi property rights in the natural resources for private producers or producers' groups requires urgent exploration. One suspects that this is the direction in which fishery management in Canada should evolve. Alternative approaches, such as (a) regulation by the federal authority of input as well as output in the fisheries[6] or (b) delegation of this function to provincial administrations, are devoid of merit. Direct measures to curtail inputs, e.g. fees charged for entry permits and royalties levied on fish landings, besides being horrendously complex and burdensome to enforce, tend to be frustrated by the competitive pressure among fishing enterprises for pieces of the common-property resource. The delegation or transfer of the fishery-management function to other levels of government is irrelevant in this connection. Such "balkanization" of the system, moreover, since it would simultaneously introduce additional sources of conflict among competing interests and remove an extant mechanism for resolving these conflicts, seems to be totally unjustifiable.

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[6] Control of output, in the sense of setting harvestable limits (TACs) for fish stocks, is an obligation of government, acting on behalf of resource owners (the citizenry in general), but these limits are in effect ultimate safeguards. Aggregate output in a rationally managed fishery, where enterprises had an incentive to equalize marginal cost and revenue, could be expected normally to fall far short of a limit established for conservation purposes.

Adoption of the strategic approach indicated, i.e. the allocation to fishing enterprises of predetermined shares in annual quotas as an inducement to secure catches at minimal cost, would have a number of implications for tactical planning in the immediate future. The design of both research and regulatory programs would be involved. The problems of application in specific fisheries would have to be investigated, which, among other things, would require (a) that the fisheries concerned be precisely defined and (b) since most fisheries include enterprises of varying productive capacity, that formulae be devised to relate rights to quota shares to investment or some other measure of fishing power. Finally, equitable arrangements (a) for security of tenure in access or quota rights and (b) through a market (auction?) or otherwise, for the transfer of these rights between fishing enterprises. Such is the agenda.

Appendix

Statistical Tables

The appended tabulations include the bulk of the material utilized or referred to in the text. Additional details and more recent data are available, on request.

TABLE 1. Atlantic sea fisheries: comparative returns, 1976. (Sources: Annual Statistical Review of Canadian Fisheries, vol. 9, and Statistics Canada, Labour Division.)

	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Participants	6 700	5 500	2 900	10 400	18 500	44 000
Fishermen/Years[a]	2 500	2 600	1 500	6 800	7 400	20 800
Aggregate earnings ($ million)						
Gross[b]	15.1	24.8	12.7	106.7	64.7	224.0
Net[c]	9.8	14.1	6.8	65.1	41.2	137.0
Individual net earnings ($)						
Per participant	1 500	2 600	2 400	6 200	2 200	3 400
Per man-year	4 000	5 400	4 500	9 600	5 500	6 600
Annual wages ($)						
Forestry	13 600	9 400	—	—	14 600	—
Mining	16 200	—	—	12 800	17 200	—
Construction	17 800	13 300	—	13 800	14 600	—
Manufacturing	11 600	11 100	8 900	10 800	11 300	—
Industrial composite	11 600	10 500	8 900	10 000	11 500	—

[a] Full-time participant = 1 m/y, part-time participant = $\frac{2}{3}$ m/y, occasional participant = $\frac{1}{4}$ m/y. See Table 5 for definition of terms.

[b] Gross value of output from the primary fishing industry.

[c] Adjusted on the basis of production-cost estimates averaging about 40% of sales.

TABLE 2. Atlantic sea fisheries: incomes of fishermen, 1972.[a] (Source: Special tabulation, Revenue Canada [Taxation].)

Income level $	Numbers included	Average gross income per head		
	no. (%)	Fishing $ (%)	Other sources $ (%)	Total $
0– 499	223 (0.9)	—1 364 (—)	1 044 (—)	−320
500– 999	390 (1.7)	281 (36.3)	493 (63.7)	774
1 000–2 499	3 418 (14.9)	661 (35.3)	1 206 (64.7)	1 867
2 500–4 999	9 803 (42.9)	1 404 (37.7)	2 324 (62.3)	3 728
5 000–7 499	5 238 (23.1)	2 871 (47.2)	3 205 (52.8)	6 076
7 500–9 999	2 143 (9.4)	4 747 (55.5)	3 805 (44.5)	8 552
10 000	1 625 (7.1)	10 573 (73.3)	3 858 (26.7)	14 431
Total	22 885 (100.0)	2 560 (50.0)	2 552 (50.0)	5 112

[a] Based on income-tax returns filed in 1973 by persons claiming fishing as their main source of income.

TABLE 3. Atlantic sea fisheries: investment and production, 1960–73. (Source: Annual Statistical Review of Canadian Fisheries, vol. 9.)

Year	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Value of fishing craft ($ million)						
1960	4.4	6.3	2.2	16.2	11.5	40.6
1961	4.6	7.0	2.4	17.0	11.0	42.0
1962	5.6	7.8	2.4	20.2	12.4	48.3
1963	7.8	10.7	2.5	27.9	16.7	65.7
1964	9.3	11.0	3.5	33.6	18.9	76.3
1965	10.1	11.6	5.4	38.9	25.1	91.1
1966	12.3	11.6	7.9	48.9	30.7	111.5
1967	16.2	14.9	9.5	59.8	52.2	152.6
1968	13.8	18.8	10.5	66.6	58.4	168.1
1969	13.4	22.0	10.0	60.4	55.7	161.6
1970	13.9	21.8	7.9	64.3	53.7	161.6
1971	13.3	22.4	8.4	65.2	50.6	160.0
1972	14.5	23.4	7.7	62.3	57.1	165.0
1973	17.8	23.1	7.5	70.0	70.8	189.2
1973/60	4.0	3.7	3.4	4.3	6.1	4.7
Primary production ($ million)						
1960	4.0	9.2	4.6	26.1	15.9	59.8
1961	4.2	7.6	4.5	27.7	14.9	59.0
1962	5.2	9.0	4.6	32.1	17.4	68.4
1963	5.6	9.3	4.6	36.2	20.4	76.2
1964	6.1	10.3	5.8	42.4	22.9	87.5
1965	6.5	10.5	7.1	49.4	24.1	97.6
1966	6.9	11.1	6.5	49.5	26.6	100.5
1967	7.4	10.8	8.2	48.2	28.9	103.6
1968	8.1	15.6	8.6	54.6	28.8	115.7
1969	8.7	15.9	8.8	56.5	30.8	120.7
1970	10.9	17.6	11.2	55.6	36.1	131.4
1971	10.6	16.1	10.4	59.4	36.8	133.2
1972	10.7	19.8	10.1	67.9	36.5	145.1
1973	12.8	22.0	12.4	76.0	47.9	171.1
1973/60	3.2	2.4	2.7	2.9	3.0	2.9

TABLE 4. Atlantic sea fisheries: fleet classification, 1973–74. (Sources: Annual Statistical Review of Canadian Fisheries, vol. 9; ICNAF List of Fishing Vessels, 1974.)

National class	Numbers of fishing craft					
	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Gross registered tonnage						
Under 10	3 100	3 000	2 400	8 000	8 900	25 400
10.0 to 24.9	100	900	100	1 000	400	2 500
25.0 to 49.9	100	100	—	100	100	400
50.0 to 99.9	ϕ	100	ϕ	100	ϕ	200
100.0 to 149.9	ϕ	ϕ	—	ϕ	ϕ	ϕ
150.0 & over	ϕ	ϕ	ϕ	200	100	300
Total	3 300	4 100	2 500	9 400	9 500	28 800

International class	Canada	Other countries	Total
Gross registered tonnage			
Under 50	28 300	—	28 300
50–149	300	400	700
150–499	200	400	600
500–999	100	200	300
1 000–1 999	ϕ	100	100
2 000 & over	—	400	400
Total	28 900	1 500	30 400

TABLE 5. Atlantic sea fisheries: seasonality of employment, 1973, distribution of employment, 1973; Atlantic groundfishery: employment trends 1960–74 (Annual Statistical Review of Canadian Fisheries, volume 9).

Extent of employment[a]	Number of fishermen					
	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Atlantic Sea Fisheries: Seasonality of Employment, 1973						
Full-time	ϕ	400	ϕ	4 000	900	5 300
Part-time	2 200	2 100	1 800	3 100	4 000	13 200
Occasional	3 300	2 500	800	3 500	10 400	20 500
Total	5 500	5 000	2 600	10 600	15 300	39 000

Fishery	Numbers engaged[b]					
	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Atlantic Sea Fisheries: Distribution of Employment, 1973						
Groundfish	3 800	1 200	800	5 300	10 400	21 500
Herring	1 500	2 100	600	2 400	5 500	12 100
Lobster	1 500	3 100	2 700	7 700	5 300	20 300
Other	NA	NA	600	2 200	5 400	11 700

TABLE 5 (*Concluded*).

Year	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Atlantic Groundfishery: Employment Trends, 1960–74						
1960	NA	2 300	1 200	6 600	15 400	NA
1961	2 900	2 400	1 600	6 800	15 400	29 000
1962	3 200	2 500	1 500	7 100	16 500	30 800
1963	3 100	2 400	1 400	7 500	17 600	32 000
1964	2 900	2 200	1 300	7 400	18 600	32 500
1965	2 700	2 000	900	7 200	17 400	30 300
1966	2 500	1 900	1 100	7 300	15 600	28 400
1967	2 500	1 900	900	6 800	14 800	26 900
1968	2 600	1 900	800	6 800	14 100	26 200
1969	2 800	1 800	700	6 200	11 500	23 000
1970	3 000	1 400	700	5 800	11 800	22 600
1971	3 500	1 400	800	5 600	11 700	23 000
1972	3 600	1 300	800	6 100	9 800	21 600
1973	3 800	1 200	800	5 300	10 400	21 600
1974	4 100	1 200	800	5 300	NA	NA

[a] "Full-time" is defined as engagement in fishing activities for 10 mo or more per year, "part-time" as engagement from 5 to 10 mo, and "occasional" as engagement for < 5 mo.

[b] Numbers engaged in more than one fishery are duplicated.

TABLE 6. Atlantic sea fisheries: major commercial fisheries, 1976. (Source: Annual Statistical Review of Canadian Fisheries, vol. 9.)

	Value of primary production (landings)					
	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Fishery	\$m (%)	\$m (%)	\$m (%)	\$m (%)	\$m (%)	\$m (%)
Groundfish	6.8 (45.0)	3.1 (12.5)	1.1 (8.7)	36.2 (33.9)	46.5 (71.9)	93.6 (41.8)
Lobster	3.4 (22.5)	6.9 (27.8)	8.5 (66.9)	22.0 (20.6)	5.3 (8.2)	46.0 (20.5)
Scallop	0.6 (4.0)	0.6 (2.4)	0.7 (5.5)	37.0 (34.7)	ϕ (ϕ)	38.9 (17.4)
Herring	0.5 (3.3)	4.9 (19.9)	0.1 (0.8)	6.4 (6.0)	3.8 (5.9)	15.8 (7.0)
Miscellaneous	3.8 (25.2)	9.3 (37.4)	2.3 (18.1)	5.1 (4.8)	9.1 (14.0)	29.8 (13.3)
Total	15.1 (100.0)	24.8 (100.0)	12.7 (100.0)	106.7 (100.0)	64.7 (100.0)	224.1 (100.0)

TABLE 7. Atlantic groundfishery: distribution of production, 1976. (Source: Annual Statistical Review of Canadian Fisheries, vol. 9; Special tabulation, Fisheries and Marine Service.)

	Nominal catches	
Species	Inshore fleets t (%)	Offshore fleets t (%)
Cod	113 100 (58.4)	80 500 (41.6)
Haddock	4 800 (24.7)	14 600 (75.3)
Pollock	6 600 (28.4)	16 600 (71.6)
Redfish	1 100 (1.2)	88 600 (98.8)
Flatfishes[a]	10 600 (9.6)	99 800 (90.4)
Other	12 900 (38.7)	20 400 (61.3)
Totals	149 100 (31.8)	320 500 (68.2)

	Value as landed	
Species	Inshore fleets \$ (%)	Offshore fleets \$ (%)
Cod	25 500 000 (59.3)	17 500 000 (40.7)
Haddock	2 300 000 (28.0)	5 900 000 (72.0)
Pollock	1 100 000 (32.4)	2 300 000 (67.6)
Redfish	100 000 (0.9)	11 300 000 (99.9)
Flatfishes[a]	2 000 000 (9.8)	18 400 000 (90.2)
Other	2 700 000 (37.0)	4 600 000 (63.0)
Totals	33 700 000 (36.0)	60 000 000 (64.0)

[a] Includes flounders, plaice, turbot, and halibut — mix varies from ground to ground.

TABLE 8. Atlantic groundfishery: composition of production, 1976[a]. (Sources: Annual Statistical Review of Canadian Fisheries, vol. 9; Special tabulation, Fisheries and Marine Service.)

	Inshore sector (%)					
Species	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Cod	82.4	50.0	42.9	47.6	91.1	75.7
Haddock	—	—	—	21.4	ϕ	6.8
Pollock	—	ϕ	—	10.7	ϕ	3.3
Redfish	ϕ	ϕ	—	—	0.5	0.3
Flatfishes[b]	5.9	37.5	28.6	4.9	4.4	5.9
Other	11.7	12.5	28.5	15.4	4.0	8.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

	Offshore sector (%)					
Species	Que.	N.B.	P.E.I.	N.S.	Nfld.	Region
Cod	62.7	21.7	25.0	29.4	23.3	29.2
Haddock	—	—	—	22.4	ϕ	9.8
Pollock	—	—	—	8.9	—	3.8
Redfish	17.6	43.5	50.0	17.0	18.0	18.8
Flatfishes[b]	13.7	30.4	2.05	12.0	53.0	30.7
Other	6.0	4.4		10.3	5.7	7.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a] In value terms.

[b] See footnote to Table 7.

TABLE 9. Atlantic groundfishery: primary production (nominal catches), 1955–78. (Sources: Annual Statistical Review of Canadian Fisheries, vol. 9; Special tabulation, Fisheries and Oceans, Canada.)

	Species (round weight)				
Year	Cod t	Redfish t	Flatfishes[a] t	Other t	Total t
1955	315 500	20 000	37 600	113 400	486 500
1956	356 100	27 000	33 700	130 800	547 600
1957	349 400	21 000	39 200	115 000	524 600
1958	289 000	27 900	38 400	107 300	462 600
1959	347 900	18 400	41 400	109 300	517 000
1960	329 100	21 300	55 100	103 800	509 300
1961	281 300	25 500	48 700	111 600	467 100
1962	318 600	27 700	46 400	116 700	509 400
1963	331 900	37 800	57 000	100 000	526 700
1964	311 000	36 400	73 400	112 600	533 400
1965	313 200	59 100	92 000	106 400	570 700
1966	306 500	83 100	105 600	118 500	613 700
1967	283 500	85 900	107 400	113 000	589 800
1968	323 100	97 400	106 600	101 400	628 500
1969	294 100	96 700	123 700	93 200	607 700
1970	262 800	108 500	135 600	72 100	579 000
1971	244 500	112 800	128 100	83 200	568 600
1972	219 100	109 900	117 000	75 500	521 500
1973	176 600	158 400	122 200	82 700	539 900
1974	156 800	87 700	98 700	74 600	417 800
1975	145 900	102 900	92 000	80 100	420 900
1976	193 600	89 600	100 400	76 100	469 700
1977	237 600	66 600	111 100	100 100	515 400
1978[b]	287 700	72 600	106 600	125 000	591 900

[a] All flatfish species except halibut and turbot.

[b] Preliminary data.

TABLE 10. Atlantic groundfishery: nominal catches, Canada, 1968 and 1976.[a] (Source: ICNAF Statistical Bulletin, vol. 18, 26.)

	Nominal catch	
Source & species	1968	1976
Gulf of St. Lawrence		
Cod	82 400	52 600
Redfish	73 500	37 500
Flatfishes	16 900	28 700
Other	7 000	5 500
Total	179 800	124 300
Scotian Shelf		
Cod	65 300	43 200
Haddock	38 400	17 600
Pollock	16 300	21 500
Hake[b]	—	—
Redfish	7 900	12 600
Flatfishes[c]	25 300	12 700
Other	7 300	9 100
Total	160 500	116 700
Grand Bank & Northern grounds		
Cod	163 100	94 600
Redfish	7 800	39 300
Flatfishes[c]	82 500	83 500
Other	3 300	6 400
Total	256 700	223 800
All grounds		
Cod	310 800	190 400
Haddock	38 400	17 600
Pollock	16 300	21 500
Hake[b]	—	—
Redfish	89 200	89 400
Flatfishes[c]	124 700	124 900
Other	18 200	21 000
Total	597 600	464 800

[a] Excludes catches from other grounds, e.g. Georges Bank, totaling 30 900 t and 4900 t, respectively, in 1968 and 1976.

[b] Silver hake or whiting.

[c] See footnote to Table 7.

TABLE 11. Atlantic groundfishery: TAC projections, 1978–85. (Source: Atlantic Coast Resource Prospects, 1978 to 1985, a special compilation of the Fisheries and Marine Service.)

	1978		1985	
Location & species	National quota t	Total TAC t	Total TAC t	Change 1978–85 %
Gulf of St. Lawrence				
Cod	60 300	82 000	106 000	+29.3
Redfish	16 000	18 000	13 000	−27.8
Flatfishes[a]	13 500	13 500	14 700	+8.9
Other	—	5 000	5 000	—
Subtotal	89 800	118 500	138 700	+17.0
Scotian shelf				
Cod	13 400	14 500	32 700	+125.5
Haddock	16 700	19 000	19 000	—
Pollock	19 600	28 000	34 000	+21.4
Hake[b]	17 200	81 000	70 000	−13.6
Redfish	13 000	20 000	30 000	+50.0
Flatfishes[a]	12 800	14 000	23 000	+64.3
Other	2 000	70 000	85 000	+21.4
Subtotal	94 700	246 500	293 700	+19.1
Grand Bank & Northern grounds				
Cod	130 100	235 000	451 000	+91.9
Redfish	68 400	100 000	93 000	−7.0
Flatfishes[a]	102 000	136 000	152 000	+11.8
Other	2 000	65 000	65 000	—
Subtotal	302 500	536 000	761 000	+42.0
All grounds				
Cod	203 900	331 500	589 700	+77.9
Haddock	16 700	19 000	19 000	—
Pollock	19 600	28 000	34 000	+21.4
Hake[b]	17 200	81 000	70 000	−13.6
Redfish	97 400	138 000	136 000	+1.4
Flatfishes[a]	128 300	163 500	189 700	+16.0
Other	4 000	140 000	155 000	+10.7
Total	487 000	901 000	1 193 400	+32.4

[a] See footnote to Table 7.
[b] Silver hake or whiting.

TABLE 12. Atlantic groundfishery: projected CPUE indices, 1985 (1977 = 1.00). (Source: same as Table 11.)

Species & grounds	Index
Cod	
Gulf of St. Lawrence	
northern area	1.21
southern area	1.34
Scotian Shelf	
northeastern area	0.60
southeastern area	0.64
southern area	1.75
Grand Bank & Northern grounds	
western area	1.21–2.17
southern area	4.03
eastern area (Flemish Cap)	1.91
northern areas (incl. Hamilton Bank)	2.00
Haddock	
Scotian Shelf	
southeastern area	1.00
southern area	1.15
Pollock	
Scotian Shelf	
southeastern & southern areas	1.98
Hake[a]	
Scotian Shelf	
southeastern & southern areas	1.00
Redfish	
Gulf of St. Lawrence	
all areas	0.56–1.00
Grand Bank & Northern grounds	
western area	0.39
central areas	1.13
eastern area	0.88
northern areas	1.13
Scotian Shelf	
southeastern & southern areas	1.50
Flatfishes[b]	
Gulf of St. Lawrence	
northern area	1.00
southern area	1.35
Scotian Shelf	
southeastern & southern areas	1.44
Grand Bank & Northern grounds	
western area	1.00–1.25
central areas	1.00–1.25
eastern area	1.00
northern areas	1.00

[a] Silver hake or whiting.
[b] See footnote to Table 7.

TABLE 13. Atlantic groundfishery: sample of fleet operations, 1976. (Source: Costs and Earnings of Selected Fishing Enterprises, Nova Scotia, 1975–76.)

	Type of fishing craft		
	Longliner	Stern-dragger	Trawler
Size class (LOA)	48 ft	62 ft	155 ft
Number of vessels	3	4	5
Avg number of crew	3.3	3.1	15.1
First date sailed	Jan. 10	Jan. 7	Jan. 1
Last date landed	Dec. 24	Nov. 26	Dec. 24
Number of trips	49	36	26
Days at sea	103	108	250
Days fishing	103	107	232
Hours fishing	1 611	1 596	2 942
Composition of landings			
Landings (avg per vessel) (lb)			
Angler	1 400	—	ϕ
Cod	153 100	103 400	1 526 200
Cusk	38 700	200	7 600
Flounders	2 200	5 500	389 400
Grenadier	—	—	2 200
Haddock	123 100	230 600	419 000
Hake[a]	52 500	600	22 000
Halibut	7 700	ϕ	11 200
Pollock	28 000	408 600	751 600
Redfish	—	—	1 022 700
Turbot	—	—	24 200
Wolffish	1 600	3 200	26 600
Other species	—	219 500[b]	87 700[c]
Total	408 200	971 900	4 290 400
Financial Performance			
Landings (lb.)	408 200	971 700	4 290 400
Value as landed ($)	81 000	94 100	397 000
Av. price realized ($/lb)	.20	.10	.09
Total receipts ($)	88 500	107 000	528 400
Total cash expenditures ($)[d]	30 300	45 700	343 700
Net crew earnings ($)	41 800	44 100	245 500
Net "boat share" ($)	16 400	17 200	−60 800
Depreciation ($)	2 900	5 700	39 800
Net profit or loss ($)	+13 500	+11 500	−100 600
Average earnings ($)			
Captain	12 500	19 500	36 100
Mate			21 200
Boatswain			16 900
First engineer			21 200
Second engineer			15 400
Cook			15 500
Firsthand (fish-hold)			13 700
Secondhand (fish-hold)			13 700
Deckhand	12 500	11 500	12 900

[a] Probably red hake.

[b] Herring.

[c] Miscellaneous nongroundfish species.

[d] Includes maintenance and repair costs, operating expenses, and fixed charges, e.g. insurance and interest.

TABLE 14. Atlantic region: Labor-force characteristics, 1977–78. (Source: Canadian Statistical Review, vol. 53, No. 5.)

	Que.	N.B.	P.E.I.	N.S.	Nfld.
Avg labor force, 1977 (000's)	2792	268	50	333	192
Avg participation rate, 1977 (%)	58.8	53.7	57.2	55.3	50.6
Unemployment Rates[a], 1977/78 (%)					
1977					
May	10.0	12.5	10.2	10.5	14.9
June	9.8	12.8	9.1	10.5	15.9
July	10.4	12.9	9.8	10.1	15.9
Aug.	10.3	13.7	9.1	10.3	16.0
Sept.	10.7	13.1	9.2	10.4	15.8
Oct.	10.9	14.0	10.5	10.4	16.8
Nov.	11.1	14.0	11.6	10.4	17.3
Dec.	11.3	14.0	11.1	10.2	17.0
1978					
Jan.	11.4	12.7	10.7	10.7	16.0
Feb.	10.9	13.4	8.2	10.3	15.8
Mar.	11.5	13.3	10.5	11.2	16.5
Apr.	11.2	14.0	11.1	11.0	16.3

[a] Adjusted for seasonal variation.

Regulating Access in Canada's Inland Fisheries[1]

D. M. CAUVIN

Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Man. R3T 2N6

CAUVIN, D. M. 1979. Regulating access in Canada's inland fisheries. J. Fish. Res. Board Can. 36: 827–836.

Uncontrolled access in Canada's inland fisheries has served neither the resource manager's interest in protecting fish stocks nor the economist's interest in promoting the most efficient use of all factors of production, including fisheries resources. Economically accessible fisheries have generally attracted more labor and capital than is required to harvest the productive potential of fisheries resources. As a result, costs of production are high in relation to the value of production and profit margins have been eroded. Of equal importance, a return from the resource in the form of a resource rent has been foregone. Access control and a price system represent management options to control excess fishing effort, promote economic efficiency in the deployment of private and public resources, and promote fiscal accountability in government.

Key words: economic efficiency, resource rent, fiscal accountability

CAUVIN, D. M. 1979. Regulating access in Canada's inland fisheries. J. Fish. Res. Board Can. 36: 827–836.

L'accès non contrôlé aux pêches dans les eaux intérieures canadiennes n'a profité ni aux gestionnaires de la ressource, en protégeant les stocks de poissons, ni à l'économiste, en favorisant l'utilisation la plus efficace possible de tous les facteurs de production, y compris les ressources halieutiques. En général, les pêcheries économiquement accessibles ont attiré plus de main-d'oeuvre et de capital que nécessaires à la récolte. Comme résultat, les coûts de production sont élevés par rapport à la valeur du produit et les marges de profits se sont rétrécies. Chose aussi importante, on a renoncé à tirer profit de la ressource sous forme de loyer. Le contrôle de l'accès et un système de prix sont deux options de gestion pouvant contrôler l'effort de pêche excessif, promouvoir l'efficacité économique dans l'utilisation des ressources privées et publiques et, enfin, promouvoir la responsabilité fiscale au gouvernement.

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THE requirements of controlling fishing effort in commercial fisheries, through access control and the introduction of a price system, are based not only on the need to protect the productive potential of fisheries resources, but to protect the fishing industry from the tragedy of dissipated profits, stranded labor and capital, and resultant economic and social hardships. Of equal importance to the need for an economically healthy fishing industry is the need to introduce economic efficiency into public resource management. Although the need for restricted entry and a pricing system has been the subject of discussion for many years, I am unaware of any success in the implementation of these requirements in Canada. While restricted entry has been initiated in certain inland fisheries, such a management strategy is regarded as an insufficient condition for control, particularly when excess fishing effort exists.

In addressing this problem, I would like to present a brief profile of the commercial inland fisheries. Second, my perceptions of the "tragedy of the fisheries" are presented. Third, the requirements for access control and a price system are applied to an inland commercial fishery. Finally, I would like to offer some personal observations of the impediments to rationalizing public fisheries management and the performance of the fishing industry. I do not feel very optimistic that rationalization will be possible.

Canada's Inland Fishery

Inland commercial fisheries production is recorded from New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, the Northwest Territories, and the Yukon Territory (Fig. 1). Annual production from this region approximates 40 000 t of fish with a landed value of \$24 million. This represents approximately 4% of Canadian fisheries production (1.1 million t) and 6% of the total landed value of Canadian fisheries production (\$390 million). (Fisheries and Environment Canada 1977). The inland lakes which are harvested comercially range in size from a few square kilometres to over 82 000 km^2 as in the case of Lake Superior. Similarly, the annual production from inland lakes ranges from a few hundred kilograms from remote

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[1] This paper forms part of the Proceedings of the Symposium on Policies for Economic Rationalization of Commercial Fisheries held at Powell River, B.C., August 1978.

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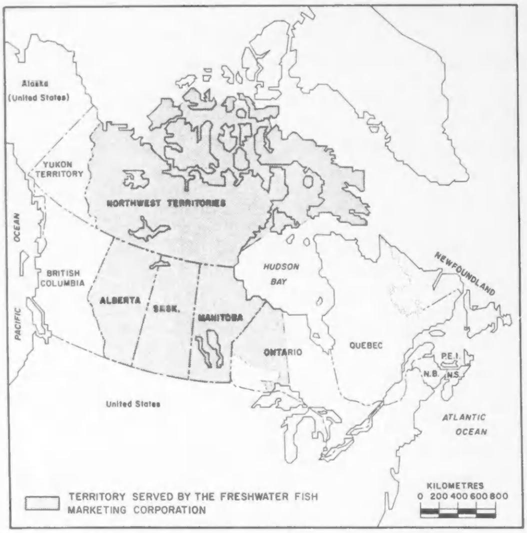

FIG. 1. Western region fisheries and area of operation of the Freshwater Fish Marketing Corporation (source: FFMC Annual Report 1975–76).

northern fisheries to over 17 000 t as in the case of Lake Erie.

There are two general marketing structures in Canada's inland fisheries (Fig. 1). The marketing structure for the inland fisheries in northwestern Ontario, Manitoba, Saskatchewan, Alberta, and the Northwest Territories resembles that of a monopsony. In this region, the Freshwater Fish Marketing Corporation, a federal Crown Corporation, has an exclusive mandate to purchase and sell all fish harvested. (Fishermen can sell directly to the final consumer.) For the balance of the inland fisheries, fishermen have access to a greater number of buyers and processors and, as a result, the industry has a more competitive structure.

Given the dispersed nature of the inland fisheries, it is dangerous to generalize concerning the performance of the commercial fishing industry. Notwithstanding the inframarginal rents generated by certain segments of the industry, however, the industry may generally be described as in a weak and declining condition. Low financial returns to commercial fisheries production and the incidence of various federal and provincial incentive and assistance programs to support the industry are regarded as evidence of the marginal economic viability of the primary level of production and the industry in general. This situation had led to the concern that many fisheries cannot operate in the absence of subsidy programs.

It is possible to define a very rough gradation of commercial fisheries in Canada's inland fisheries with respect to economic viability and development. This perception appears to follow S. Gordon's observation of a "continuous gradation of fishing grounds in respect to their productivity" (Gordon 1953).

At one end of this continuum, it is possible to define economically accessible fisheries such as Lake Winnipeg in Manitoba and Lake Erie in Ontario. These fisheries have a relatively long history of commercial fisheries production and are capable of supporting an economically viable fishing industry. However, they have generally attracted much more labor and capital than is required to harvest the productive potential of the resource. As a result, the costs of production are excessive and profit margins have been eroded. In addition, fish stocks have subsequently declined. This situation is aggravated by regulations designed to protect fish stocks from excessive fishing effort and by subsidies which inhibit natural adjustments in the industry infrastructure.

At the other end of the continuum, it is possible to define economically inaccessible fisheries such as the Savage Island fishery in northeastern Manitoba or the Athabasca fishery in northern Alberta and Saskatchewan. These fisheries are effectively accessible only by aircraft. Depletion of fish stocks and the dissipation of profit margins resulting from too many fishermen chasing too few fish is not a problem in these cases. Rather, the cost of transportation is such a major constraint that the price of fish available to fishermen, net of transportation costs, is insufficient to permit adequate returns to labour and capital. Nevertheless, it can be argued that to the extent that these fisheries depend on subsidies for their existence, inaccessible fisheries are also subject to excess fishing effort. It would appear that the primary purpose of maintaining these fisheries is to provide "productive unemployment" on the premise that it is less expensive and more socially desirable than the dispensation of direct welfare.

Over 70% of inland fisheries production is marketed in the United States. The balance is marketed in Canada, Europe, and Asia. The prices that can be expected for inland fisheries production and the ability of the Canadian industry to survive is, therefore, largely dependent on the productivity of the American fishing industry. This has important implications for the development of an economically efficient Canadian inland fishing industry.

The Tragedy of the Fishery

The literature on fisheries economics attributes many of the problems in fisheries management to the management of the resources as common property. Uncontrolled access coupled with the rule of capture, forces fishermen to compete for the available harvest. As a result of this competition, there is little incentive to restrict fishing effort in the interest of maintaining fish stocks because any fish that an individual leaves may be captured by another.

For economically accessible fisheries, at least, this situation has resulted in the dissipation of the economic value of the resource to the detriment of the fishing industry and to society. First, we find an industry characterized by production costs that are excessive relative to the value of production. Fishermen, therefore, will often find themselves in an untenable position with considerable investments in vessels and equipment that cannot be liquidated, and few employment opportunities that are consistent with their skills and experience. Second, as a result of excessive fishing effort, and despite harvest control measures, the fisheries resource is subject to depletion. Finally, the potential economic value of the resource to society in the form of a resource rent is essentially foregone. In this situation, Canadian citizens, who pay the cost of management through taxation, receive, at best, some questionable secondary benefits (e.g. employment, conservation of fish, regional growth and development, value added in the industry).

The question of who should receive the rent raises at least two philosophical questions. Who owns the resource? What is the principal objective to management? It is my opinion that while fisheries resources have been managed primarily for the user groups, the resource stockholders, of which fishermen are only a subset, are Canadian or provincial citizens who incur the tremendous costs of management through taxation. It is also my position that the principal objective of resource management should be to assure that fisheries resources contribute to the welfare of the resource stockholders. This objective may be attained by maximizing the difference between the cost and value of the resource. To the extent that there is an interest in economic efficiency in public fisheries management, this will require the extraction of a rent.

The solution to the problem of controlling fishing effort, which appears favored by some economists, requires the control of entry into a fishery. Restricted entry, related to the minimum investment in fishing effort required to harvest the productive potential of economically accessible fisheries, provides an initial control. However, experience with the west coast salmon fishery, where an attempt was made to control fishing effort through a license limitation program, suggests that restricted entry is an insufficient condition for long-term control (Munro 1977). A necessary condition for long-term control requires the introduction of a price system, such as a royalty on landed value, to control aggregate fishing effort at an equilibrium position lower than that which would occur when fish are priced at zero.

The Lake Winnipegosis Fishery: A Hypothetical Assessment of Empirical Data

Commercial fishing on Lake Winnipegosis was an established industry in the 1880s. During the early 1900s lake whitefish (*Coregonus clupeaformis*) was the principal species harvested. From the 1920s to the mid-1960s, however, walleye (*Stizostedion vitreum vitreum*) represented the greatest proportion of the harvest and was regarded as the most important component of the fishery. In recent years the composition of the catch has changed to the extent that suckers (*Catostomus* spp. and *Moxostoma* spp.), a low valued product, now represent the greatest proportion of the volume harvested.

Coincident with the decline of the pickerel population, the fishing industry, particularly the primary sector, has suffered a decline. Fishing is generally featured by low financial returns to fishing enterprises, dependence on government subsidies, and the absence of public returns from the resource. These are classic features of a mature fishery that is managed as a common property.

If we can accept the economic solution to this problem, requiring restricted entry and a pricing system, we might consider Bell's proposition that the purpose of the fisheries management "... should be to promote the highest efficiency in the use of vessels and fishermen as is our purpose in every other sector of our economy" (Bell 1977). Based on this proposition, we might also consider Pontecorvo's observation that "efficient utilization of resources requires that a transfer of capital and labor out of the fishing industry, which would increase the value of output to another industry, would not decrease the value of the output of fish" (Pontecorvo 1977). It is highly unlikely that a reduction of labor and capital on Lake Winnipegosis would reduce the value of the output of fish. Rather, it is likely that the net value of production to the industry would increase and rents would emerge.

The hypothesis that a reduction in the number of fishing enterprises on Lake Winnipegosis would result in an increase in the net value of production to the industry is easily predictable and should not be considered startling. However, the emergence of rents and the implications of extracting a return from the resource to the public sector accounts have not, in my opinion, been adequately articulated. To the extent that there is an interest in promoting efficiency in the industry and fiscal accountability in the public sector, the following assessment of the Lake Winnipegosis fishery provides 1. a cursory examination of projected production based on existing harvest control measures and proposed harvest control measures; 2. a brief examination of the performance of a "representative" fishing vessel under three optional fisheries policies; 3. an examination of the public accounts for the management of Lake Winnipegosis as they relate to the present value of commercial fisheries production to the public sector.

These findings are illustrative only and are not intended to be precise predictions of future events.

Harvest Control Measures and Projected Production

Lake Winnipegosis is being managed primarily for walleye (*S. vitreum vitreum*). In this regard, the summer quota is 318 t of pickerel plus the incidental harvest of other species, including lake whitefish

TABLE 1. Projected production, Lake Winnipegosis, 1977–96.

	Maintenance of existing harvest controls			Revision of harvest controls		
Year	Pickerel (t)	Incidental (t)	Total (t)	Pickerel (t)	Incidental (t)	Total (t)
1977	180	1090	1270	70	410	480
1978	90	540	630	70	410	480
1979	45	270	315	70	410	480
1980	20	110	130	90	550	640
1981	30	160	190	110	690	800
1982	140	820	960	140	790	930
1983	160	950	1110	160	890	1050
1984	45	270	315	180	980	1160
1985	25	150	175	200	1100	1300
1986	20	120	140	230	1140	1370
1987	40	245	285	250	1200	1450
1988	40	245	285	280	1250	1530
1989	40	245	285	300	1300	1600
1990	40	245	285	320	1340	1660
1991	40	245	285	340	1360	1700
1992	40	245	285	360	1380	1740
1993	40	245	285	390	1390	1780
1994	40	245	285	410	1390	1800
1995	40	245	285	430	1380	1810
1996	40	245	285	450	1360	1810

(*Coregonus clupeaformis*), saugar (*S. canadense*), northern pike (*Esox lucius*), and sucker (*Catostomus* spp. and *Moxostoma* spp.). In addition to the quota, harvest control measures include the regulation of the size of gillnets used to 10.2-cm mesh and the length of gillnets to 4600 m per license.

In spite of the existing control measures, pickerel stocks are declining and provincial biologists are concerned that unless harvests are reduced the species will be replaced by less desirable species. The decline is expected to be evidenced by radical oscillations in annual pickerel production, as harvests become more and more dependent on strong single year-classes, and a general reduction in the annual harvest (Adams 1977). Because of the concern for declining fish stocks, provincial biologists have advocated a reduction in the pickerel quota to 70 t for 3 yr and an increase in the minimum gillnet mesh size to 11.4 cm.

Table 1 illustrates projected production on Lake Winnipegosis on the assumptions that (1) no changes in regulations take place and (2) that the advocated regulation changes are initiated. In the event that regulations remain unchanged it is estimated that the harvest will be dependent primarily on a single immature age-class with insufficient escapement to assure consistent recruitment. As a result stocks would be expected to decline over time. An increase in mesh size and a reduction in the annual pickerel harvest for 3 yr is expected to broaden and increase the age-class distribution of the harvest and thus permit the escapement of a greater percentage of mature fish, reduce dependency for recruitment on a single age-class, and permit stocks to recover in 3-yr (Adams 1977). The resultant projected harvest of pickerel is expected to increase over time to 450 t (Manitoba Department of Renewable Resources and Transportation Services 1976).

PERFORMANCE OF A REPRESENTATIVE FISHING ENTERPRISE

The primary level of the Lake Winnipegosis fishery consists of 45 licensed fishermen. Since additional entrants are no longer permitted, these 45 licensees represent the upper limit to the number of fishing enterprises. Harvesting is conducted with gillnets from 11- to 14-m vessels. A four-man crew is physically capable of fishing and dressing 2700–3600 km of fish per 8–10-h d. This productive potential, however, has not been realized in recent years. Rather, average daily production has ranged from 140 to 545 km. This range reflects not only the harvest control measures and declining populations of fish, but also the fishing effort expended by individual fishermen.

To the extent that the productivity of the labor and capital engaged in harvesting the resource is as equally important as the protection of fish stocks, it is of interest to obtain a perspective of the performance of the fishing industry on Lake Winnipegosis. Such a perspective may be obtained by assessing the present values of future cash flows for a "representative" fishing enterprise under three optional fisheries' policies:

1. Option I: Maintenance of the Status Quo — Option I entails maintenance of the existing fleet of 45 vessels and the continuation of present harvest control measures.

TABLE 2. Present value: 20-yr pro forma statement of a representative fishing vessel (values in $000's).

	Present value[a]	Investment	Net present value	Internal rate[b] of return (%)
Option I	−58.4	29	−87.4	Negative
Option II	−5.3	29	−34.3	Negative
Option III	37.0	29	8.0	11.25

[a] A discount rate of 10% has been used to discount future cash flows to demonstrate the minimum expected rate of return. Obviously the expected rate of return will vary according to tne expectations of individual fishermen.

[b] The internal role of return equates the present value of cash flows with investment requirements.

2. Option II: Natural Attrition of the Fleet — Option II entails the institution of a licensing system involving the provision of lifetime nontransferable licenses to existing fishermen and the introduction of the advocated harvest control measures.

3. Option III: Optimum Fleet Reduction — Option III entails a reduction in the fleet to 20 vessels and the institution of the advocated harvest control measures.

Table 2 illustrates the performance of a representative fishing enterprise under the three optional fisheries' policies. This information is derived from pro forma statements constructed for a fishing vessel, sharing equally in the available harvest, in accordance with the number of vessels and harvest control measures articulated in the policy options.[2] Essentially, the information presented represents a capsulization of the discounted net cash flows of the pro forma statements. Predictably, a reduction in the number of fishing vessels results in an improvement in the performance of the residual fleet.

Obviously, the maintenance of the status quo serves neither the interest in maintaining the productivity of fish stocks or the interest in enhancing the productivity of labor and capital engaged in harvesting the fish stocks. The present value of the cash flows is negative. To the extent that investments in the fishing enterprise may be regarded as "sunk" and the variable costs of operation can be covered, the enterprise will continue to operate in the short run. In the long run, however, it would be expected that the enterprise would exit from the fishery because the present value of the cash flows will not cover new investments. It is of interest to note that government subsidy and assistance programs will have a tendency to retard this process.

Based on the demographic age structure of Lake Winnipegosis fishermen, the institution of nontransferable licenses to existing fishermen would result in a reduction in the size of the fleet to 29 vessels over 20 yr through retirement of existing fishermen. Despite the relative improvement in the performance of the fishing industry, it is apparent that the recovery period is slow. The enterprise is still not capable of generating a sufficient cash flow to cover investments. From this point of view, option II is not considered to be particularly attractive.

A reduction in the size of the fleet to 20 vessels, on the assumption that such a deployment of labor and capital represents the most efficient use of resources, results in a very positive improvement in the performance of the industry. The representative fishing enterprise is capable of earning a long-run return on investments. Of equal importance, the industry is capable of operating in the absence of subsidy programs.

In conclusion, it is apparent that while access control is capable of enhancing the performance of the industry, the necessary adjustments on Lake Winnipegosis would not be costless unless excess labor and capital could be readily transferred to alternative employment alternatives. Further, it is highly unlikely that a government "buy-back" program to reduce the size of the fleet could be justified. Such a program would add materially to the public costs associated with the management of fisheries resources. Management agencies are thus on the "horns of a dilemma." Failure to control access and reduce the size of the fleet will perpetuate the current performance of the industry. At the same time, efforts to reduce the size of the fleet through methods other than natural attrition would likely result in social and economic dislocation.

PERFORMANCE OF THE PUBLIC SECTOR

Richard Bird (1976) has observed that "the arguments for pricing products produced by the public sector whenever possible are really the same as those for the pricing in general. . . . The economic case for pricing in the public sector rests essentially on the contribution that pricing, particularly marginal-cost pricing, can make for allocative efficiency." If there is an interest in economic efficiency in the public management of fisheries resources, as well as in the industry, it is necessary to consider the performance of the public sector. Further, if there is agreement that efficiency in the public management of fisheries resources is independent of the costs and revenues generated by the private sector in moving fish from lake to market, it may be possible to agree that efficiency in the public management of commercial fisheries resources requires that the public sector maximize the resource rent. I prefer that rent, where it exists, should accrue to the public sector accounts rather than to the accounts of the industry. First, it is a means of converting Canada's resource wealth into internal growth and development. Second, it provides a tangible means of resource valuation for making public investment and allocation decisions. Third, it provides an important control on fishing effort. Finally, by requiring a balancing of public revenues (rents) and expenditures, it will contribute to the accountability and productivity of government resource management programs. Rent can be extracted by pricing the provision of fisheries resources through a royalty on landed value.

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[2] Details on projected production, revenues, and costs are available from the author.

Failure to price the provision of fisheries resources at their economic costs results in distortions in "demand" signals and pressure on government to expand the "supply" of resources to satisfy the requirements of the beneficiaries. The importance of pricing fisheries resources is, therefore, twofold. First, it provides a price control on the demand for fisheries resources and makes fishermen aware of the economic costs of management. In this situation it is not only possible to generate revenue and control demand, but to obtain price-quantity information to measure demand signals. Second, by requiring fishermen to pay for fisheries resources, signals are generated, on the basis of their willingness to pay, of whether the provision of fisheries resources should be expanded or contracted. These signals provide information that is necessary for government to measure the economic value of fisheries resources in commercial production, to assess its expenditures in the supply of the resource and, thus, to make efficient investment and allocation decisions.

The economic value of the Lake Winnipegosis fisheries resources in commercial fisheries production to the public sector may be determined by discounting net revenues (royalties and license fees minus the cost of management) over time. This is a calculation of government's capitalized share of the resource rent. It does not include the full social net value, which would include rents left to the private sector in the form of super or excess profits. However, the net values accruing to the private sector are regarded as external to the public accounts. In this regard, there is an interest in measuring the contribution of the public sector activity of "growing" fish. This is of particular importance if there is an interest in economy efficiency and fiscal accountability in the public sector.

The discounted net revenues, known as the net present value or capitalized value, represents the value of the resource in commercial fisheries production to the public sector based on what the resource is capable of earning. Because the public sector has traditionally charged a zero or nominal price for the right to fish, the public sector has generated net costs rather than net revenues. From this perspective, the fishing industry is being subsidized. It can be argued, therefore, that the value of fisheries resources in commercial fisheries production to the public sector is largely negative. This situation has created some profound problems in making resource investment and allocation decisions. In considering the evidence, it is of interest to review the public accounts for the management of Lake Winnipegosis (Adams 1977).

Table 3 illustrates the performance of the public sector for three optional management policies which parallel those presented in assessing the performance of a representative fishing enterprise. The information presented is a summary of the discounted public sector revenues and costs associated with the management of Lake Winnipegosis.[3] To the extent that the allocation of public fisheries resources to commercial fisheries production should yield a positive return to the resource, it is apparent that the performance of the public sector in the provision of fisheries resources requires improvement.

TABLE 3. Present values: 20-yr statement of public accounts (values in $000's).

	Present value of gross revenues	Present value of management costs	Present value of net revenues
Option I	28	1046	−1018
Option II	26	1046	−1020
Option III	733	537	196

Looking briefly at options I and II, it should be noted that the present values of gross revenues, which are generated through license fees, differ according to the rate of attrition in option II. Given the costs of managing Lake Winnipegosis and the revenues generated through license fees, the present values of the resource in commercial fisheries production are greater than minus $1 million. Is it any wonder that alternative uses of water displace fisheries production? Given the prospective returns to the public sector, the question might be asked how much of the taxpayer's dollar can we afford to invest in the public management of fisheries resources. The absence of a resource rent does not enhance the ability of the resource manager to measure his productivity.

A reduction in the size of the fleet provides the opportunity not only to improve the performance of the private sector, but to improve the performance of the public sector. Referring to option III, the increase in the present value of gross revenues reflects the initiation of a royalty on the landed value of fisheries' production. To obtain a positive net present value, however, it has been necessary to reduce management costs. This situation, which is illustrated in the present value of management costs, reflects the proposition that the introduction of a price system provides signals to expand or contract government services. The present value of $196 000 provides a measure of the economic value of the resource based on what the resource is capable of earning. It provides a measure of the value that society will forego (opportunity cost) if commercial fisheries production is displaced. It also provides a foundation for making public investment decisions in increased fisheries production.

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[3] Details on projected production revenues and costs are available from A.S.

CONCLUSION

The foregoing analysis represents an attempt to demonstrate the application of economics to the management of fisheries resources. Access control is required to attain an efficient deployment of labor and capital and assure a return to resources engaged in harvesting fish. A price system is required to control demand and to measure the productivity of public expenditures made in supplying fisheries resources. For the public sector accounts the net revenues generated provide tangible evidence of value in making fisheries investment and allocation decisions. Unfortunately, there are a number of impediments to the initiation of such a proposal by the federal government in Canada's inland fisheries.

Impediments to Economic Rationalization

The potential contribution of economics to fisheries management has been articulated for over two decades in Canada. It would appear, however, that this potential contribution has largely been ignored. Is it as Scott has suggested that we have focused on the distributional aspects of fisheries management to the exclusion of economic efficiency (Scott 1965). Based on my experience, I am inclined to concur with Professor Scott. From my experience, the impediments to the adoption of economic efficiency in the management of inland fisheries include institutional constraints, conflicting objectives, and administrative constraints.

INSTITUTIONAL CONSTRAINTS

"While it is a common part of Canadian federation that both the federal and provincial governments have dual roles in many areas of Canadian life, the situation with respect to the freshwater fisheries tends to be more complicated in the intricacies of federal–provincial jurisdiction. The result has led, at times, to genuine confusion as to the management prerogatives over the fisheries of the inland waters. This situation has arisen as a result of the constitutional development of Canada and the adoption of British Common Law to the Canadian situation" (Thompson 1974).

The distribution of legislative powers between the federal government and the provincial governments are specified in part VI of the British North American Act, 1867. Section 91 of the Act, which delineates the legislative authority of the federal government, includes, as an example of exclusive federal legislative responsibility, the seacoast and inland fisheries. The probable intention of the Act was to place complete control of fisheries under one jurisdiction. However, there was a failure to recognize the legal implications attached to fisheries and the ambiguity in our constitution relative to provincial rights.

At common law, we must define two types of fisheries in Canada — the "proprietary fishery" and the "public right of fishery." The proprietary fishing is characterized by an exclusive right to fish. The right to fish or the ownership of the fishery is directly connected to the ownership of the bed of the watercourse. In Canada, proprietary fisheries exist only in the nontidal inland waters. In the case of the public right of fishery, the relationship between the ownership of the watercourse and the ownership of the fishery in navigable waters was annulled by the signing of the Magna Carta in 1215. (Attorney-General for British Columbia vs. Attorney-General for the Dominion of Canada 1914). At common law navigable waters are those in which the tide ebbs and flows. In Canada, therefore, the public right of fishery exists only in tidal waters.

While section 91 of the BNA enumerated seacoast and inland fisheries as within the legislative competence of the federal government, it failed to recognize provincial ownership rights of nontidal proprietary fisheries. Therefore, while the federal government exercises legislative jurisdiction over both the seacoast and inland fisheries, it cannot exercise proprietary rights over fisheries it does not own. As a result, two levels of government exercise control over nontidal fisheries. On one hand, the federal government may legislate with respect to fishing seasons, quotas, size limits, and gear control. On the other hand, the provincial governments have the right to determine who can fish, what privileges are conferred, and what fees they will pay to do so.

The solution to this anachronism has been achieved by delegating the responsibility for the administration of federal legislation of nontidal fisheries to the provincial governments. Thus, for example, the Fish and Wildlife Division of the Alberta Department of Recreation, Parks and Wildlife, administers both federal and provincial legislation with respect to fisheries. In addition, provincial governments may recommend changes to federal fisheries regulations made under section 34 of the federal Fisheries Act. Upon review, approved amendments are passed by the Privy Council as Orders in Council and are gazetted to become law. Thus, the regulation of inland fisheries is undertaken as a cooperative endeavor between the federal and provincial governments with the responsibility for administering legislation delegated to the provinces.

Despite the delegation of authority, the federal government maintains a constitutional responsibility to provide for the regulation and protection of all fisheries in Canada. It is also of interest to note that the federal government exercises control over fisheries under its responsibility for interprovincial and export trade. Nevertheless, the diffuse nature of federal–provincial management responsibilities and the inability of the federal government to exercise proprietary rights represents a major institutional constraint to the federal management of inland fisheries (Thompson 1974).

CONFLICTING OBJECTIVES

I was under the impression that the objectives of the "greatest good for the greatest number of people over the longest period of time" has been rejected on the grounds that it is impossible to simultaneously maximize two, let alone three, conflicting variables (Gordon 1958). It is somewhat disconcerting to note, therefore, the apparent conflict in the objectives of federal and provincial agencies, whose programs have a direct impact on fisheries management. The objectives of increasing incomes, increasing employment, conserving fisheries resources, and promoting regional growth and development may seem quite unexceptional at first glance. However, when they are directed to a fishing industry that is characterized by excess labor and capital, low average incomes, and the requirement of perpetual government subsidies, conflicts become apparent.

The Canada–Manitoba General Development Agreement, a development agreement entered into by the government of Manitoba and the federal Department of Regional Economic Expansion in 1974, provides an example of objectives that impinge on the rationalization of the inland commercial fishing industry. The development principles of this agreement include the "implementation of an effective stay option through policies and programs which will prevent Manitobans from being coerced by economic forces to leave their province or to leave the region within the province in which they prefere to live . . .". (Canada–Manitoba General Development Agreement 1974). Objectives emerging from the principles of development include "socio-economic" development in northern Manitoba and increased incomes and employment opportunities throughout Manitoba.

The "stay option" is of particular interest to note. Economic growth and development has historically involved "breaking-down the old and building the new." This process has involved mobilizing resources, including human resources, to new locations and new opportunities. In this regard, it is felt that an important function of government is to assist in the adaptability and mobility of human resources to opportunities that exist for growth and development. It would appear that the stay option is a major impediment to mobility. It would also appear that fisheries are looked upon as a primary means of exercising this option. First, fisheries resources are physically available. Second, entry into the industry does not require a high level of investment. Third, while entrepreneurial skills appear absent from many of our fisheries, unemployed labor is generally assumed to be readily adaptable to fishing.

The objectives of the General Development Agreement to increase employment and increase incomes are also of interest to note. Despite the fact that a reduction of labor and capital from economically accessible fisheries, such as Lake Winnipegosis, would increase the net value of production, the observations of Gordon (1962) do not appear to be convincing to the resource manager: ". . . if one works on the assumption that it is the objective of an industry to provide employment and that it is good to provide employment, I think one will always find oneself at odds with the results of economic analysis because economic analysis proceeds from the thesis that it is not work we want — work is what we have to do in order to obtain other things we want — and that if we find ourselves in an economy in which work is not available, then something is wrong with the whole economy, not the particular industry that is under study. It may be true that in the interest of the economy as a whole we are favouring policies that tend to increase employment, but this will never be true as far as a particular industry is concerned, because unemployment is a symptom of a far more general problem than anything that can be attacked through intervention in one industry."

The resource manager challenges the basic premise of economics that resources are scarce. Fisheries managers may agree that fish are scarce and that the future holds the dismal prospect of a protein shortage. However, it would appear that resource managers consider human resources, our most important resources, to be redundant. Even the perceptions of Crutchfield (1962) are questioned: "In a more fundamental sense, it must be emphasized that maximum employment for a given output is a nonsensical objective (except in periods of severe general unemployment, when it could be regarded as a form of work-sharing). The unprecedented growth in economic welfare in the western world has been achieved by getting more output with less inputs. North American living standards reflect our continuing success in meeting basic needs (particularly for food) with fewer and fewer resources, thus providing the basis for expansion of both capital and consumer goods industries. The record of the northwest regional economy in the postwar period certainly indicates ample ability to absorb the small increase in the total labor supply which would result from a reduction in the size of the halibut fleet. The question at issue is fundamental: do we use the gains of the conservation program to support more marginal fishing units, or do we provide better incomes to those actually needed and produce more of other things"?

The problems of the unemployed, immobile, and inadaptable human resources are a serious source of concern. The problems are particularly acute where remote northern fisheries, which are economically inaccessible, are looked upon as a "spring-board" for regional growth and development. I am concerned about the finite capability of fisheries resources to solve these problems. I would like some assistance in grappling with the question of whether the fishing industry should be a sump for immobile and inadaptable labor. The maintenance of an inefficient fishery, based on the premise that it provides the least expensive and most socially desirable means of dispensing welfare, may be a short-term solution to the problems associated with immobile and inadaptable labor. However, there is a danger of developing an industry infrastructure based on the requirement for perpetual government subsidies. There is also the danger that long-term solutions to the underlying problems of immobile and inadaptable human resources will never be addressed. In this case, there is a possibility of perpetuating short-run problems. How can we transfer these resources to more productive activity?

ADMINISTRATIVE CONSTRAINTS

Public resource management has traditionally been the domain of the natural scientist. In his role as a fisheries resource manager, the biologist's interest has been directed, primarily, to the protection, enhancement, maintenance or "conservation" of physical stocks of fish. In pursuing this interest, a system of management has evolved requiring the employment of various harvest control measures designed to protect fish stocks. Unfortunately, in the process of focusing on fisheries resources, labor and capital resources have been largely ignored. As a result, the harvest control measures (including closed seasons, closed areas, quotas, and restrictions on fishing effort and technology) have constrained the efficiency of the industry and the ability of the industry to adjust to changing market conditions. To mitigate the resultant inefficiencies in the industry, the resource manager has initiated a number of assistance programs (including vessel and freight subsidies, price support, equipment grants, and ice harvest assistance) to enhance the performance of the industry. In the process, we have strayed a long way from the management of fish. We have strayed into the role of welfare agency, employment agency, regional stabilization agency, and, in general, a fishing industry support agency. This situation is reinforced by other government agencies whose responsibilities also include welfare, employment, and regional growth and development.

To the extent that economic efficiency in the harvesting of fisheries resources and in the public management of resources is as desirable in Canada's inland fisheries as it is in other sectors of our economy, it is apparent that fundamental changes are required to control the "tragedy of the fishery." In the case of public fisheries resources, the exercise of Crown proprietary rights through restricted entry and the initiation of a price system to ration and allocate scarce fisheries resources represent management options that deserve consideration. The apparent difficulties confronted by management agencies in exercising proprietary rights to control fishing effort suggest that the fishing industry has assumed control of fisheries resources. They also suggest that management agencies are not confronted by a requirement for fiscal accountability.

Despite the legal interpretation of the British North American Act, 1867, and the subsequent division of responsibility between the federal and provincial governments, it is my perception that the fishing industry exerts a great deal of influence on how and for whom fisheries resources will be managed. This is a problem common to regulatory agencies and one which should be expected to occur in the case of fisheries management. The enforcement of traditional harvest control measures, through a proliferation of regulations designed to protect fish stocks, has had a tremendous influence on the performance of the industry. It is natural, therefore, for the industry to be critical of what might be perceived as additional constraints on its ability to harvest fish efficiently. Despite the fact that access control would permit the relaxation of traditional control measures, there is an apparent reluctance to accept new management incentives. Certainly, the proposed imposition of a royalty on the landed value of British Columbia salmon as a control measure has met with a predictable negative response from the industry. The fishing industry, being extremely rational, will agree only to those programs that are of direct and immediate benefit to the industry. As a result, attempts to rationalize the industry and fisheries management are often frustrated.

I am unaware of any resource management agency in Canada that is required to balance expenditures with revenues (rents) generated from the management of public resources. Rather, government expenditures are assumed to equal benefits and enter into our national accounts as zero. While this may conform to accepted accounting convention, I consider it to be dangerous. Essentially, it frees public management agencies from direct accountability for their expenditures. In this sense, government fisheries management is not regarded as an integral component of the fisheries production process. Budgets are not, for example, predicated on the contribution of fisheries management to the economy as a discrete activity. We must look to performance indicators generated in the private sector, such as value added, as a measure of the contribution of resource management and as justification for public expenditures. While there may be real values generated in the private sector, it is also possible that the potential rent from fisheries resources may not only be dissipated by the private sector, but also by the public sector. A review of our public accounts appear to substantiate this statement. According to the public accounts of Canada, the costs of fisheries management, research, and other fisheries and Marine Service activities approximated $152 million during 1973–74. These expenditures include activities such as hydrographic charting and environmental toxicology. The output of these activities extends beyond the management of fisheries resources for commercial use. Revenues generated during this period totaled $5 million (Finance Canada 1974). These statistics clearly indicate that someone is being subsidized. During 1974, the contribution of the primary level of the fishing industry in terms of the gross value of production was recorded at $291 million (Fisheries and Environment Canada 1977). If the value added by the primary level of the industry approximated 50% of the gross value of production, the expenditures of the Fisheries and Marine Service would exceed the value added by the primary level of the industry. If you are concerned with the distributional consequences of this accounting system, it is important to note that the Canadian taxpayer incurs the tremendous costs of management, the benefits of which accrue to certain segments of the industry.

Conclusion

To summarize, it can be demonstrated that entry control and a price system can generate tangible benefits to the commercial fishing industry and to public fisheries management. It is possible to generate economic returns to labor, capital, and the resource. To conclude, however, without a radical change in the environment in which fisheries managers function, it is highly unlikely that economic efficiency will ever become an integral part of management.

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Symposium on Policies for Economic Rationalization of Commercial Fisheries

PART IV

Some Special Issues

Perspectives on Fisheries Biology and Implications for Management

L. M. DICKIE

Department of Fisheries and Oceans, Marine Ecology Laboratory, Dartmouth, N.S. B2Y 4A2

DICKIE, L. M. 1979. Perspectives of fisheries biology and implications for management. J. Fish. Res. Board Can. 36: 838–844.

Descriptions of fisheries systems for purposes of management often seem to imply a naturally predetermined biological structure and functioning of the resource. However, such basic characteristics as stock definition, species composition, levels of production, and biological efficiency are parameters that have generally been adapted to suit particular fishery conditions and in any case are variables that interact with both environment and the nature of industrial exploitation. In the interests of economic or social analyses in fisheries these biological descriptors should normally be amenable to redefinition or redescription without prejudice to their reliability as indices of natural production.

Key words: fisheries management, economic objectives, unit stock concept, variability, fisherman's choice, predator–prey relations, biological and technological efficiency

DICKIE, L. M. 1979. Perspectives on fisheries biology and implications for management. J. Fish. Res. Board Can. 36: 838–844.

Les descriptions de systèmes halieutiques pour fins de gestion semblent souvent sous-entendre une structure biologique et un fonctionnement de la ressource prédéterminés naturellement. Cependant, des caractéristiques fondamentales telles que définition du stock, composition par espèces, niveau de production et efficacité biologique sont des paramètres généralement adaptés à des conditions particulières et qui d'ailleurs sont des variables réagissant à la fois avec le milieu et la nature de l'exploitation industrielle. Pour faciliter l'analyse économique ou sociale des pêches, ces descripteurs biologiques devraient se prêter normalement à une redéfinition ou redescription sans que soit affectée leur fiabilité comme indices de production naturelle.

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FISHERIES management has generally aimed to find an objective scientific basis for regulation. This aim assumed particular importance in the period of the great international marine fisheries where countries with very different social and economic objectives and different political procedures for realizing them still felt a need to reach common agreement on a method for controlling fisheries expansion. The biology of fish stocks and the need for conservation provided the required common ground and during the 1960s and 1970s acquired a priority position in the development of strategies and rules of management.

Similar motivations emerged at various stages during discussions leading towards agreements on a new Law of the Sea. Biologists were often surprised at the avidity of administrators and lawyers for what appeared as almost wisps of information. However, even very general scientific categorization or description was often sought in the effort to give at least the appearance of an objective base to negotiations which otherwise dealt with a disturbingly faceless and subjective world.

It has been a primary aim of the sciences to categorize and describe those parts of the universe with which they deal. Translation of the impression of surroundings into objective units necessarily precedes quantification and calculation. However, what this interest in scientific description seemed to have lost sight of was the scientist's recognition that there is interdependance between description and calculation. A certain description permits certain calculations. But in scientific activity, it frequently happens that the need to examine new questions, or to make different calculations, dictates a requirement for a new description of the physical or biological units employed. A quest for the ultimate physical or biological unit carries with it the risk of creating its own illusions.

During this symposium questions about the nature of the biological resource system have arisen a number of times. From the discussions I have inferred that realization of some current economic and social objectives for fisheries could be inhibited by a too narrow or doctrinaire view of the biological constraints. It is inevitable that concepts used in biological assessments of fish populations should incorporate assumptions, speculations, or results of a perceived need to "play it safe," especially in rapidly changing or new situations. Furthermore, there has been a significant growth of biological knowledge and points of view during the past two decades and by no means all of them have yet

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been incorporated in management technologies.

This essay attempts to highlight some features of biological resource analysis and ecological modeling that bear on perceptions of the new management needs that have arisen with the advent of 200-mile zones of exclusive economic jurisdiction. It is my view that it is important to respect the aims of the biological conservation paradigm that has guided so much of past fisheries management. However, it does not follow from this that it is necessary to be bound by the rules or methods through which we have tried to realize these aims. The scientific evidence suggests that description and treatment of the fisheries system can often be readapted to fit new needs of management without sacrificing an underlying reality.

The "Stock" Concept

Biological management of fisheries has been built around the concept of "the unit stock." At this late stage in development it is difficult to discern that this apparently commonsense notion may be an instance of misplaced concreteness which places artificial constraints on analyses or on management rules and procedures. In fact, the "stock" is an abstract term applied to provide a rationale for a certain kind of aggregation of catch data. This is not to say that there may or may not be such a thing as a discrete group of fish that may constitute an effective breeding group or stock, but in many cases there is significant uncertainty about the identity of the group from which successive annual catches are made, so that the operational term does not unequivocally refer to an identifiable physical entity. Uncritical usage can obscure the understanding of a number of production features that are relevant to economic considerations.

The concept of the unit stock arose in response to what appeared as a practically insurmountable problem in resource inventory. The need was for an estimate of abundance and future yield of exploited populations. It was initially thought that this could be obtained from information on density of fish in the area of their distribution. Since special surveys were prohibitively expensive, there was an intention to use the fishing fleet as a sampling instrument. "Catch per unit effort" by a fishing vessel should be a function of density, which under certain conditions might be converted to the requisite abundance information.

Much fisheries research in the 1950s and 1960s was devoted to experiments designed to permit the development of standardized abundance indices from catch per unit effort data. The attempt was generally unsuccessful. The results showed instead that there was an enormous variability and bias in catches as population samples. Some of this variation and bias could be associated with areas, seasons, gear, and types, sizes, and mixtures of species caught. However, in many cases it was also clear that the expectations, motivations, knowledge, or expertise of fishermen had a very important effect. In some cases the nature of the fleet distribution was such that total catch appeared to be a better reflection of relative abundance than was catch per unit effort. But in nearly all cases the result meant that catch per unit effort information on a routine basis would be expensive and unreliable as a measure of abundance.

As is frequently the case, the answer to the urgent problem of measuring total abundance came from an unexpected source. Work in closed freshwater environments led several fisheries scientists to the realization that if successive catches in an area could be considered to come from a single stock, and the age distribution of the catch was known, then the sum of catches of a given cohort throughout its life in the fishery would give an estimate of at least the minimum abundance of the stock when it was first vulnerable to fishing. Several methods were proposed for correcting this estimate of the minimum to more nearly the actual abundance. Furthermore, on the basis of the argument that if fishing efficiency is constant the real amount of fishing is reflected in the catch itself, both abundance and fishing mortality rate could be derived from catch data without any need to resort to interpretation of confusing data on the amount of fishing done by various gears at different times and places. With the apparently high rates of fishing in effect by the late 1960s, many series of catch data were adapted to analyses of this sort and the method quickly became the basis on which estimates of total allowable catches (TAC) were made in the framework of international fisheries commissions.

This system of analysis, generally referred to as "virtual population analysis," solved the immediate management problem by stepping around the major difficulty. The assumption could be made that certain subsets of catch statistics reflected samples from a given "stock." It then does not matter that this stock may be spread over an unknown or variable area, may vary greatly in density, and be fished by various fishing gears. As long as total catch and age distribution are known, estimates of abundance can be made. The more years' data available, the better the retrospective estimate of initial stock size.

While the method permitted management to make urgent short-term management decisions, there are biological difficulties posed by the use of the unit stock. The most important is that there is still no way in which the data can be referred to an identifiable and measurable biological production unit. There are, therefore, severe limitations on our ability to predict or explain trends in production in relation to changes in either fishing or natural environmental influence. Of more immediate importance, however, are the limitations that the methodology places on practical national management. Under international jurisdiction fishery laboratories of national governments became very largely directed to the service of fishery assessment and the estimation of TACs. In most cases these laboratories found it necessary to abandon their studies of variation in catch per unit effort as unjustifiable luxuries. As a consequence, the quality of fishing effort data may have suffered where it has been collected at all. Ironically, a few years later, under the 200-mile limit, it is precisely information on catch per unit effort that becomes preeminently important for the framing of detailed fishing plans, or in efforts to improve fishing efficiency and prosperity by eliminating the waste associated with unnecessary or ineffective fishing activity.

It is a matter of some importance to economic management objectives to recognize this basic assumption of fisheries assessment technology. The unit stock used in management is in many cases as much a function of past fishery practise as it is a function of fish biology. It follows as a consequence that if economic or social objectives call for a redefinition of fishery practise, biological assessment should generally be able to support it by a redefinition of unit stock which would not be an appreciably inferior index of the biological system on which the natural production depends.

Management for Stability

Regulation of fisheries has traditionally allowed the highest possible total yields consistent with conservation constraints. However, year-to-year stability is of such importance in our social structure that managers, particularly in coastal states, have considered the possibility of some sacrifice to immediate gain in the interests of improved regularity. Unfortunately, the mystique of conservation which has surrounded management, may have led us to expect regulation to play an unrealistically important role in stabilizing yields. What is worse, because of our ignorance of the factors affecting population stability, management rules may be exaggerating the catch variability they are intended to ameliorate.

Stability in a system is an attribute of the interaction of the components of that system with each other. Thus, for example, we define systems primarily by the property that the sum of variations in component parts is much greater than variations in the overall sum of these parts. In fisheries, it is well recognized that the catches of individual species vary from year to year. It is less commonly recognized, though widely demonstrated, that the sum of the catches from particular areas is relatively stable in time, exhibiting trends which may be quite different from changes in individual species. The interactive or system nature of fisheries production seems undeniable. The concern of management is whether there are functional relations between the variations in landings of individual species and the total, and whether these may result from natural biological interaction or from the activities of the fishery.

Population interactions in fisheries may be generally considered in two categories: competitive or predatory–prey. Competitive relations arise through the dependance of two animals on the same resource, such as food. Predator–prey relationships make up the complex food-chains on which production depends. These two classes of natural interaction tend to have different effects on production and on the relation of fishing to stability of yields.

Competitive relationships have always occupied an important place in evolutionary thinking. However, from the point of view of the ecology of production processes, what stands out is the extent to which different species have evolved mechanisms to avoid direct competition. It is a fair generalization that two naturally occurring fish species share the same food resource only when that food is not in short supply. In times of scarcity most species become narrow specialists. It follows, that competitive relations are of importance primarily within species, tending to restrict the abundance of the species in accordance with the productive capacity of the environment.

It is a consequence of competitive effects that the numbers of fish that survive into adulthood are generally less variable than the numbers of fish larvae in the water, and that the numbers of larvae are generally less variable than the numbers of eggs that may be spawned. This does not mean that competitive effects lead to stable production of year-classes, because aquatic environments are highly variable. It does mean, however, that where competitive effects predominate, as may be the case with predators at the top of the food chains, population abundance may be predictable from a knowledge of environmental parameters. It may also mean that where fishing pressures become very heavy, production of top predators may become less stable due to the reduced importance of the stabilizing competitive relationships.

Predator–prey interactions are more difficult to generalize because our knowledge of them is still so fragmentary and some of the predators in which we are interested may at some stage of their life be prey for others. It is known that at certain body sizes predators tend to specialize in particular foods, changing to larger food items as they grow. However, the selection of food items varies over time and may depend on prey abundance. That is, predators may concentrate on an abundant food species, virtually exterminating it, while at other times if the same prey species is rare, predators may virtually disregard it. Many predators depend heavily on the larval or juvenile stages of their prey species, about which we still know very little. Thus, while biological production underlying fisheries depends on predation, our knowledge of the details for individual species is so scanty as to make predictions nearly impossible.

Despite the difficulty of making predictions about particular species, current research in this area is revealing certain system features. For example, it has been shown that when areas such as tropical islands are depopulated by severe storms, reestablishment of biological communities follows a predictable sequence. The first colonists are opportunistic species among which a characteristic food-chain or trophic structure is soon established. Subsequent immigrants may displace the first, substantially altering the species composition. But the trophic structure, in terms of numbers and types of predator–prey links, is stable. That is, while species composition changes from time to time and in response to external factors, the overall biological functioning of the system in terms of production is much more constant.

It appears that this phenomenon may be exhibited most dramatically in some of the major pelagic ecosystems of the world. The crash of the Peruvian anchoveta population and its fishery is a recent and widely quoted example. This stock was heavily affected by fishing, but there is growing evidence that following the anchoveta decrease there has been a compensatory shift in the balance of species towards an anchoveta–sardine–horse mackerel assemblage where biomass is surprisingly similar to the former anchoveta biomass. If this proves true, the Peru case joins a number in other parts of the world that have not only exhibited remarkable recent species-composition changes, but according to the fossil record have experienced similar changes, even before the appearance of intense fisheries.

It remains an important ecological and practical question to establish whether or not in some situations there may be key species whose predatory activities are such as to dominate the dynamics of the whole community. Candidate species for such a role have sometimes been advanced but the computer models designed to study them are still unconvincing representations of reality.

While this evidence on predator–prey relations is unsatisfactorily anecdotal, there are some practical consequences that are soundly enough based to serve as preliminary management guides. In the first place, because predator–prey effects are generally destabilizing influences in communities, it is unlikely that we will ever be able to make long-term predictions for particular species. In fact, conservation regulations cannot guarantee the persistence of any particular species. The best we can hope for is that the biological sciences should eventually be able to provide relative probabilities of persistence of given types of species in relation to levels of exploitation. For example, it can confidently be predicted that heavy exploitation of a top predator, such as codfish, will give rise to an increase in the biomass of its prey, such as herring and capelin, thus improving the prospects for direct fisheries on these intermediate species. It is equally likely, however, that as a result of fishing, these intermediate food-chain species will exhibit unaccountably high variations in abundance and catch from time to time.

The bulk of the evidence indicates that variations in the local abundance of individual species do not signal impairment of the natural production system. If a fishery occurs near an ecosystem boundary or depends on intercepting fish on a broad migratory path, there are bound to be variations in local fisheries. We need to learn to predict them. But their existence is an index of the general dynamism that will continue to affect catches despite our best attempts at deterministic control by species. The implication of their continued presence is that the most practical objective of management is the determination of long-term potential yield levels and the fishing strategies they require, while working to develop mechanisms of self-regulation with respect to the shorter term changes.

In the light of popular concern about the possible effects of natural biological interactions on fisheries yields, it is ironic for management that the most important aspects of interaction within the fisheries system probably result from activities within various levels of the industry. In what must surely become a classic in the analysis of fisheries data, Carlson (1975) showed that over a 4-yr period nearly half of the variations in annual landings by the trawl fishery of Georges Bank could be related to various measures of the fishing effort used to make the catch. However, when the same landings were converted to annual revenues by the vessels, the fishing effort statistics explained more than 85% of the variation. These results demonstrate in dramatic fashion the power of fisherman's choice. That is, the results make it clear that fishermen, using information on the availability of fish and on the prices for fish, were effectively able to manipulate their activities so as to maximize their revenues. We have here an index of the power of fishermen to bias their sampling, giving substance to our earlier recognition of some of the reasons for variations in catch per unit effort.

The most important implication of Carlson's results, however, rests in the demonstrated power of fishing operations to determine revenue levels in spite of natural variations in species abundance. The strength of the relationship suggests that the ability of fishermen to choose among alternative activities may be the dominant force translating variable individual species catches into stable overall output.

There is an immediate important implication for management. Present biological management, partly because of a tendency of processors and markets to deal with species, tends to set conservation constraints on a species by species basis. In fact, TACs are generally established for individual "stocks," and fishing privileges are granted on a stock, area, and sometimes seasonal basis. That is, the regulations are implemented in a manner that reduces fishermen flexibility. While Carlson's analysis does not enable us to calculate the actual additional cost of such restrictive measures, his results suggest that it must be of an order fully comparable to the apparent costs of initial short-term catch reductions.

In light of growing evidence on the probabilistic nature of community balance and the natural variability of species, it appears that we should be seriously questioning the necessity or appropriateness of a priori deterministic management. Regulation systems based on single species quotas were probably necessary under the unwieldiness of international administration. The situation under 200-mile zones of national jurisdiction contains the possibility of greater sensitivity to realities of fishing practises and costs.

Relations Between Technological and Biological Efficiency

Attempts to improve the prosperity of fisheries are inevitably concerned with technological efficiency. In Canada, management has considered that advice to industry on technological improvements in catching power is one of its major responsibilities and there have been a number of important studies of the productivity of vessels of different types and sizes in relation to requirements of both manpower and capital. Generally, however, these studies have assumed a fixed level of productivity of the biological system. The evidence suggests that there may be very important interactions between the type of technology and the biological efficiency of the exploited resource.

This obscurity of the relation between biological and technological efficiency appears to be an inadvertent legacy of the stock concept discussed above. Biological assessment of the stocks was concerned to calculate maximum sustained yield or MSY of the stock. Since, however, the whole concept of MSY arose from the difficulty in determining local densities and areas of distribution, predicted yield was not initially related to any considerations of the efficiency with which it could be captured, or of the efficiency with which this yield of fish was produced from the basic biological production. There has been virtually no ground for common understanding with the economics of fishing. It is only with the advent of national jurisdictions and increased concern for economic efficiency that attention of the biologists has once again been seriously turned to questions of density distributions of biomass and food-chain efficiencies. While research is still at a very early stage, there are features of the system which are well enough known to provide a common ground for discussions and joint long-range planning by biologists and economists.

It is common knowledge that marine fisheries production takes place through rather complex food chain systems. Most fisheries production comes from the larger organisms near or at the end of these food chains. It is also understood that there are large energy losses between successive links of food chains. The prospect of tapping the very high production at the levels of the small planktonic organisms has long intrigued the hopeful. In answer to the question, "Why not?", it is repeatedly pointed out that while the production of these planktonic producers is certainly several orders of magnitude higher than that of the tertiary producers caught by fisheries, there is a general relation between rate of production, size of organism, and dispersal. The planktonic producers are generally of very small size and highly dispersed. The effort and energy required to find and collect them is often prohibitive for most large organisms.

There are local exceptions to this rule, due to the heterogeneity of the oceans, and of the tendency of organisms to school. Both give rise to local concentrations. Whales capitalize on the concentrations of Antarctic krill, and commercial fisheries have been able to successfully catch shrimps. On the average, however, it has been found that while food chains in the sea form a pyramid of numbers, the weight or biomass per unit volume of seawater of organisms at the various levels of the food chain is very nearly a constant. The myriad of numbers of the smaller fast-producing creatures, while generally being somewhat clustered, may thus appear to be very dispersed in the volumes which must be searched or strained by a large predator.

Although with foreseeable technologies there are still substantial difficulties with economic cropping of the base of the food chains in the oceans, the general characteristics of natural food-chain exploitation provide useful models of methods to maximize efficiencies of fishing within existing technologies. Two general features are of immediate significance.

First, it should be noted that the observed biomass distribution of various sized organisms in the sea reflects more or less equilibrium conditions in which the biomass of the successive trophic levels is a function of both their own food density and of the predation on them by higher food-chain levels. When fishing is introduced, the biomass of the exploited stock decreases, as does the amount of prey items it consumes. The result in most cases will be an increase in the biomass of the prey organisms. Because of the general energy relations between successive predator–prey steps, the increase in prey biomass may sometimes be several times larger than the decrease in predator biomass. Hence as noted earlier, judicious exploitation of certain predators will sharply increase the probability of successful fisheries on their prey organisms. This effect may account for increases in fisheries for pelagic species such as herring, following the early development of intense fisheries for their predators, the large cod or salmons. While these pelagic fisheries have shown high variability, their contribution to the total landings has been notable. An improved knowledge of food-chains may suggest other possibilities for joint management of species or species groups.

Second, it is worth noting how natural food chains are maintained. The present catch of an individual predator is a function of the average density of prey in the water it searches. However, the predator's total catch from a given area over an appreciable period of time is a function of the rate at which the removed prey biomass is replaced. Because the rate of replacement of an organism is closely related to its size, it follows that the size of prey organism is critical for the predator. If prey organisms are too small, they may be so dispersed that the predator cannot satisfy its immediate energy needs. If the prey organism is too large, the predator's immediate energy requirements are satisfied, but a low rate of replacement of prey items would mean a low probability of a repeat performance unless the total population of predators was very small. In general, among the predators the balance of individual requirements and population size seems to respond to prey size, through the twin influence of the linked properties of dispersal and replacement rate.

Clearly parallels with this natural system exist for the fishing industry. Individual fishing units of given size and investment require a certain catch per unit effort to meet costs and fulfill profit expectations. The strategy for an individual vessel will be to fish the largest sizes (or in certain cases schools) of fish available to it. However, as fleet size grows, the probability of high catches of large individuals decreases and the fisherman is forced to land the smaller sizes which, while not as abundant are more often there. The advantage for industry as a whole is that in harvesting smaller organisms the total yield is greater. Other things being equal, therefore, the socially desirable higher total yields would be best ensured by using the same strategy that nature uses, that is, by reducing the average sizes (requirements) of the individual predators (fishing vessels) and increasing their total numbers.

There are of course, many practical considerations in translating this simplistic biology into economic fishery practice. For one thing, large vessels may be required to exploit waters distant from home ports. For another, the utilizable yield of small organisms may be lower than that of larger organisms of the same or closely related species. Furthermore, the economic efficiency of certain fishing technologies is not necessarily a function of the size of the vessels concerned. Such problems are clearly matters for investigation and calculation in individual cases. The general point here is that economic yield in fisheries is a function of both technological and ecological efficiency, and both aspects should be taken seriously in making long-term projections of the types and sizes of fishing fleets that are desirable.

Concluding Remarks

The foregoing was written in the hope of helping to break down some of the communication barriers that still exist among the groups engaged in fisheries management. There are persistent difficulties between economists and biologists. But individuals in each of these disciplines also seem to understand situations differently when cast in the role of researcher, academic, or administrator. The fact is that in such a complex undertaking, all the various categories of participants need what guidance they can get from each other in distinguishing between "fact" and "opinion" in the framing of advice. Even greater difficulties have to be surmounted in an effort to reach a common agreement about the relevance of information in one discipline to deliberations in another.

In trying to bridge this gap it is inevitable that personal prejudices should creep into both the selection of material and its presentation. For example, in traditional descriptive field biology, most thinking has revolved around the species. In management practise, the tendency has been to attempt to deal with analytically smaller units, such as populations or stocks. In the foregoing I have implied the possibility of using a quite different set of population criteria such as body size and average density, disregarding the fact that different species may be involved — a line of argument considered inappropriate by some biologists. For purposes of initiating constructive interdisciplinary discussion, it probably does not matter who has espoused which view for what reason. The need is for nonbiologists to understand the possibility of flexibility in description of the biological system for different purposes. It is my belief that this approach allows the possibility of finding common ground where sometimes it seems as though none exists.

Aside from the influence of personal taste in some matters, however, there are aspects of the foregoing commentary which I believe can be taken on their own merits. One very important consideration is the contrast between the seemingly very deterministic fisheries world of management and the flexible, probabilistic world as seen by the fisherman and the research worker. The deterministic management approach taken in the past has its own historical justification and seemed to fulfill particular needs of management under the international fisheries commissions. However, almost everyone concerned recognizes that agreements on Law of the Sea have revolutionized the social and political setting of fisheries. The new situation calls for far more than historical justification of our institutions.

In the new regulation systems required, there is little doubt of the importance of taking into account the interactive and flexible community nature of the resource base. The aim to achieve certainty and precision through quantification of the biological system seems rather to have revealed a complex stochastic network of relations in which the uncertainty and changing values of the parameters are reminiscent of the situations studied by economists. Such characteristics suggest that the two disciplines have more in common in developing future management policy than past performance has indicated.

If this proves to be the case it necessarily calls into question an important feature of present management procedures, in which priority consideration is paid to conservation requirements for the species. That is, data are now collected and analyzed by biologists to provide an estimate of TAC. These estimates are reviewed and adopted before the formulation of fishing plans and the implementation of strategies to distribute the resulting economic and social benefits.

There are two weaknesses in this methodology. First, TACs have to be based on retrospective stock estimates. Therefore, especially in very intense fisheries, data from the 1st yr of fishing contains very little predictive information and a TAC based on them alone would be little more than a guess. In fact, several year's data are used in calculations and this year's estimates of TAC include compensatory corrections for last year's imprecision. The priority criterion used to control fishing is not, strictly speaking, a strong predictive instrument. Second, the variable nature of the component species with overall stability implies that the interactive forces in the community are naturally compensatory. That is, along with the flexibility and variability is a good deal of resilience and robustness of system functioning. A priori controls do not take advantage of such natural system properties.

With the newly perceived importance of using fisheries resources to satisfy social and economic objectives, there would appear to be good reason to use the natural homeostatic properties of populations to the fullest possible advantage. That is, the evidence points to the possibility and practicability of reversing the priority order in which management strategies are generally framed and put into effect. There is every reason to suppose that management systems can be set up that are designed to respond sensitively to social and economic objectives and in which the requirements for resource conservation can be fully and effectively protected by a posteriori adjustments of landing rights rather than by the imposition of a priori constraints. Such systems would not likely decrease the effectiveness of precision of conservation controls, however, there is a strong likelihood that they would decrease administrative costs and eliminate many industrial inefficiencies. Such possibilities should make strong candidates for early consideration in bioeconomic management.

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Implications of Multipurpose Fleets and Mixed Stocks for Control Policies[1]

D. D. HUPPERT

National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, CA 92038, USA

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Management of harvests from mixed stocks and multipurpose fleets requires the use of concepts not discussed in single species fishery models. Optimum harvest of a group of mixed stocks implies that an aggregate objective pertaining to the multispecies catch is maximized. This usually prohibits the attainment of the maximum sustained yield or the maximum economic yield for each individual stock. Operation of a multipurpose fleet is economically justifiable when there are significant annual or seasonal fluctuations in fish stock abundance. A simple linear model is developed in this paper to demonstrate how the multipurpose fleet can be a necessary part of rational management.

Key words: economics, management, multispecies

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Pour gérer la récolte de stocks mixtes par des flottilles polyvalentes, on doit faire appel à des concepts qui ne sont pas examinés dans des modèles de pêcheries d'espèces uniques. La récolte optimale d'un groupe de stocks mixtes suppose que l'on porte au maximum un objectif composite par rapport à des captures de plusieurs espèces. Pour cette raison, il est ordinairement impossible d'atteindre le rendement maximal soutenu ou le rendement économique maximal pour chaque stock. Il est économiquement justifiable d'exploiter une flottille polyvalente quand il y a d'importantes fluctuations annuelles ou saisonnières d'abondance des stocks. Nous élaborons dans cet article un modèle linéaire simple démontrant la façon dont une flottille polyvalente peut être partie nécessaire d'une gestion rationnelle.

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FISHERIES management science has not adequately addressed the problems associated with mixed biological stocks and multipurpose vessels. Both situations influence the economic and biological analyses required for optimization of the harvest. In the case of mixed stocks, the concept of maximum yield must be adapted to a multispecies aggregate rather than being applied on a stock-by-stock, or species-by-species basis. Economically desirable harvest rates for mixed stocks depend upon relative prices of the species caught and upon the costs of altering the species mix. In the first section below I review recent literature on mixed stock management and summarize the conclusions for fisheries policy.

Multipurpose vessels shift from fishery to fishery in response to seasonal fish abundance, closures by management, or fluctuations in prices and costs. Any economic or biological factors that cause economic returns to fluctuate can induce vessel operators to diversify in an attempt to improve long run earnings potential or to decrease annual variations in income. Although economically irrational management methods may often be responsible for the appearance of multipurpose fleets, there are many situations in which investment in multipurpose vessels is justifiable. The examination of conditions favorable to multipurpose fleets and the determination of optimum size for a multipurpose fleet are the main subjects of the second part of the paper.

In developing an analysis of mixed stocks and multipurpose fleets, it was necessary to abstract from some of the more detailed problems of fishery regulations. Companion papers in this symposium by Adasiak (1979), Crutchfield (1979), Fraser (1979), and Scott (1979) draw more attention to the problems of regulating fisheries than I do. In particular, the cost minimization in the traditional economic efficiency approach to management requires that capital investment in fishing capability be limited. This requirement is often identified with license limitation programs, and I adopt this position in the discussion of optimum multipurpose fleet. The overinvestment may be transformed, however, from a problem of too many vessels to one of vessels that are too big or heavily equipped.

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Fraser is especially concerned that license limitation, and even restrictions on the total tonnage of the fleet, will not satisfactorily constrain the investment in fishing vessels and gear. Rather than repeat the arguments presented elsewhere, I refer the reader to the other papers in the symposium. In general, the whole spectrum of regulatory methods discussed in these other papers is applicable, with modification, to multiple stocks and multipurpose fisheries.

Management of Mixed Stocks

Several investigations of mixed stock fisheries have appeared in recent years. Among these are Anderson (1975, 1977), Clark (1976), Hilborn (1976), Hobson and Lenarz (1977), and Paulik et al. (1967). The papers by Hilborn and Paulik et al. treat the specific problems associated with mixed stocks of salmon. Conditions characterizing the salmon management problem are (1) the thorough mixing of many substocks of economically identical fish at sea, (2) the inability of fishing vessel operators to avoid the contemporaneous harvest of fish from more than one stock, and (3) the lack of biological interactions which affect the productivity of the individual stocks. All the other authors identify several categories of mixed stock fisheries. Hobson and Lenarz (1977) seem to have the most comprehensive taxonomy of mixed stock fisheries. Fish stocks may be ecologically interactive or not, and fishing gear utilized in the fishery may be flexible or inflexible.

The first characteristic, degree of interaction among stocks, depends upon the relationship of species in a food web. Stocks of predator fish may be food limited, thus implying a positive relationship between the number of predators and the size of the prey stocks. Two species may compete for food, in which case the size of one stock may be inversely related to the size of the competing stock. Finally, the several stocks being exploited may be neither competing for a common food source nor preying on each other.

The flexibility of the gear in targeting upon a single species or a subgroup of species depends upon both the physical characteristics of the gear and upon the spatial and behavioral attributes of the fish. When fish from several stocks are essentially identical as in the salmon fishery, the fishermen may realistically be assumed to have no practical means of discriminating among the several stocks available at a given time and place. Fishing gear that sweeps a given area is generally less selective among fish species or stocks than gear that requires that a target species have a particular physical or behavioral attribute. Trawl nets are perhaps the archetypical example of sweeping gear. Pacific halibut, for example, are taken in conjunction with a variety of other flatfish species by bottom trawlers. Longline gear, on the other hand, can discriminate against the smaller flatfish species because a larger hook prevents smaller fish from being caught.

Adding to this complexity is the great variability in species mix that any given gear type can achieve by selection of temporal and spatial deployment. At different times of day or in different seasons of the year, the species available to trawl gear differ radically. Also, a given species can mix with another species during certain life stages but not during others. In all of the published papers on management of mixed stocks, this richness of detail is sacrificed to the analytical tractability of the models. Those generalizations that I find promising for mixed stock management policy are discussed under the following two headings: (1) optimum harvest rates and (2) the incidental catch problems.

OPTIMUM HARVEST RATES

Existing analyses all seem to agree on one important aspect of the joint harvest problem. When the fishing gear used to harvest one or more mixed stocks is incapable of targeting upon single stocks, it is agreed that (1) the maximum harvest rate for the aggregate of stocks will be less than the sum of the theoretical maxima of the individual stocks, and (2) the less productive stocks will have to be reduced to levels that cannot support their individual maximum yields, and the more productive stocks will be exploited at rates close to, but generally less than, the individual stock maxima. Some stocks may even be driven to extinction by an aggregate sustained yield maximizing policy. This result leans heavily on two key assumptions: (1) that maximum physical yield is the objective, and (2) that the gear is inflexible. Different objectives and more flexible gear lead to different conclusions.

Preservation of genetic diversity, for instance, may be an important consideration. This particularly concerns biologists studying the effects of heavy exploitation of salmon stocks. From an economic standpoint, genetic diversity may have great value if it preserves future options and acts to increase overall productivity over time. Another major consideration is the relative economic values of the mixed species. For salmon this may not be of critical importance, but in groundfish harvests there are often high-valued species of relatively low productivity or great vulnerability mixed with larger stocks of lower-valued species.

Both Anderson (1975) and Clark (1976) derive conditions necessary for the economic optimization of mixed stocks. The value to be maximized is the aggregate sales value of the mixed catch minus the harvest cost. Just as in the single species models popularized by Gordon (1954) and Schaefer (1957), the economic optimum is examined by converting the physical yield curve into a value curve measured in dollars. When a two-species harvest is introduced, the economic value curve has two local maxima. The annual net economic yield is maximized when the marginal cost of fishing just equals the marginal sales value of the mixed catch. Since there will generally be two rates of harvest satisfying this condition, the overall economic optimum occurs at the point that has the higher total net value. From a theoretical standpoint this is all that is needed. In practice, however, the aggregate biological yield is difficult to determine, especially when the two stocks being harvested interact biologically. Also, unlike the "biological" maximum, the economic optimum will not necessarily sacrifice the less productive stock to fully exploit the more abundant stock. If the smaller, more vulnerable stock has an extremely high value relative to the more abundant stock, the economic optimum may well dictate a low rate of exploitation which protects the small stock and leaves the large stock relatively underexploited

Flexibility of the gear in targeting on individual species may provide a means to avoid retarding the development of a larger fishery to protect a small, high-valued stock. Flexibility implies that the relative harvest rates of mixed stocks can be adjusted by gear modification or targeting, while overall exploitation rate is controlled, as usual, by the total amount of fishing. For each possible relative rate of harvest of two species there will be a theoretical economic yield curve with two peaks. If it is assumed that the unregulated fishing vessels adopt those fishing methods that yield the greatest net revenue, then any alteration in fishing methods will result in an apparent reduction in earnings or increase in costs. But a regulated modification of relative harvest rates may result in a long-term increase in total sustainable economic yield. An optimal adjustment of relative harvest rates requires that the rate of increase in fishing costs be balanced at the margin against the rate of increase in equilibrium value of harvest.

INCIDENTAL CATCH PROBLEM

Among the most difficult and frequently occurring problems in fisheries management is the incidental, or by-catch problem. The general approach to mixed stock management discussed above does not include any mention of incidental catches simply because we assume that managers accept the mixed catch and optimize over the range of possible relative and aggregate rates of fishing. Under the multiple species approach, incidental catch is not a problem or nuisance. In what sense, then, can an "incidental catch problem" occur? It seems to me that the problem has two sources: (1) institutional or political inflexibility in setting objectives, and (2) technological and enforcement shortcomings.

If managers are committed to manage on a species-by-species basis, then each fishery management unit may become a proponent for the particular group of fishermen and gear types that specialize on its species. Each species management group will want to promulgate as many direct controls (gear regulations, season and area restrictions, and incidental catch allowances) as are necessary to protect its species and to maximize the yield from its species. Under this sort of management institution it will be very difficult for any central authority to adopt a rational aggregate approach to the mixed stocks. Not only will the scientists studying each species develop a narrow viewpoint, but the operators in each separate group are likely to become a political force supporting the continuation of the enforced separation of fisheries. There will be no special interest group to protest the onerous economic costs that such a system will impose on society as a whole.

It must be admitted, however, that appropriate mixed-stock management procedures will not necessarily accomplish the ideal relative harvest rates without imposing incidental catch regulations. It is possible, for instance, that catch of some depleted but high-valued species should be prohibited. If this conclusion is economically rational, it is implied that there is some technological means of avoiding the prohibited species at reasonable cost. Economists often recommend the use of tax incentives to encourage desired behavior or discourage undesired behavior. When the behavior (or fishing technology) occurs outside the manager's observation range, however, it may be impossible for a tax or fee system to work. Obviously, the incidental catch can be discarded at sea while the economic rewards and/or penalties are applied at the point of landings. Control over fish landings, therefore, is unlikely to provide adequate protection to a prohibited species.

Once it is concluded that landings regulations or taxes cannot enforce the desired fishing rates, other direct regulations may be considered. The imposition of any kind of gear requirement, or season or area restrictions, should be preceded by a demonstration that the long-run increase in potential catch value exceeds the increase in harvest costs. In conclusion, the problem of regulating incidental catches can arise in rational mixed-stock management programs, but the frequency of such problems would probably be greatly reduced if multiple species management approaches were adopted.

Management of Multipurpose Fleets

Despite its relevance to fisheries management, multipurpose vessel operation has been subject to few penetrating analyses. Meany (1977) has recently written one of the few overviews of the pertinent issues. Five reasons for fishermen to invest in multipurpose capability are identified by Meany. These are (1) changes in relative abundance of different species, (2) changes in relative prices of species, (3) seasonal factors, (4) differential changes in gear costs, and (5) personal preference of the skippers. Like any successful businessman, the fishing vessel owner must periodically assess the profitability of various production methods. When conditions change, the profitability of fishing changes, and the fishermen must adapt.

Meany goes on to develop a hypothetical scenario involving successive imposition of limited entry to four interrelated fisheries. All vessels with historical participation in a given fishery are issued licenses to fish in that fishery. Over time this results in unequal treatment of newcomers who can fish only in the less-developed fisheries. As more fisheries become heavily exploited, they are put under license limitation programs. Eventually, a bewildering array of single and multiple fishery licenses emerges. Under this system of limited entry there is far too much potential effort for some species (due to the inclusion of all past participants), while at the same time some vessels have too little flexibility in fishing methods to survive the inevitable failures of recruitment in individual stocks. The system, in other words, protects neither fish stocks nor fishermen. Meany's conclusions for fishery management are (1) multipurpose fleets should be managed as a unit by limiting access to the multi-species group of fisheries; (2) the optimum number of vessels in the group should be determined in accordance with maximum sustainable yield, maximum profit, or some other socially acceptable objective; (3) changing conditions imply changes in the optimum fleet size and managers should be prepared to increase or decrease the fleet size; (4) differential license fees should be introduced for each fishing method to shift effort from the more heavily exploited to the less heavily exploited fisheries; and (5) licensing regulations can be supplemented, if necessary, by gear restrictions and other forms of catch regulation. Under this recommended system, fishermen are free to decide (subject to fees and gear restrictions) which of the fisheries they will enter during any given year.

Implementation of an economically rational management program of the type that Meany recommends will depend crucially upon the ability of the managers to determine the optimum fleet size. This will be true regardless of which regulatory methods are adopted. To examine how one might accomplish this task, I have developed a simple two-stock model. I assume that the two essential aspects of economic rationalization, regulation of the catch and regulation of long-term commitment of resources to fishing and processing capital, are separable. Although optimum extraction rates and optimum capital stock can be derived formally from a single optimizing model (see Clark 1977; Anderson 1975; Smith 1969), separation of the two problems has practical value. Rates of exploitation will often be determined through intensive interaction among biologists, economists, fishermen, and managers. Any proposals for further regulation aimed at cost minimization will be developed largely by economists. Controls on fleet size, therefore, are in practice often appended to some preexisting plan for controlling catch.

The discussion of optimum fleet size is developed in two parts. In both, the annual allowable catches are assumed to be interpreted as fishing quotas which are enforced through season closures. Under Case I, it is further assumed that the annual quotas are fixed and recurring year after year. Case II examines the implications of random variation in the fish stocks which is reflected in annual variation in the two quotas.

CASE I — FIXED ANNUAL QUOTAS

The two fish stocks may be potentially available to the fishing fleet throughout most of the year or they may be available in two discrete seasons due to natural variations in availability. In either case the development of a two-stock fishery can be examined by reference to Fig. 1. A fuller algebraic development of the model is contained in the Appendix. Only a verbal explanation will be attempted in the main text. In both panels of Fig. 1 the number of vessels in the fleet is measured along the horizontal axis.

In the upper panel the curve labeled R represents the level of revenue minus operating costs earned per vessel. As the number of vessels is increased the net operating revenue, R, proceeds through three stages. As N increases from zero up to the number required to fully utilize the quota of the more profitable stock (assumed to be stock 1), the profit per vessel remains constant. If the two stocks are available all the time, then until the number of vessels exceeds N^*, no vessels fish the less profitable stock. Only stock 1 is fished because the quota is taken at a slow enough rate to allow full utilization of the fleet. If the fishing vessels are earning sufficient profits to attract additional fishermen into the fishery for stock 1, however, the fleet will continue to expand. As the number of vessels expands beyond N^*, the net revenue per vessel declines because each vessel must stop fishing for the more profitable stock 1 when the quota is reached. An increasing fraction of the available fishing capacity will be devoted to the less valuable second stock.

With free access to the hypothetical fishery the eventual size of the fleet is determined by the prospective profits and the capital costs associated with owning a fishing vessel. It is usually realistic to assume that additional fishing vessels will be built to enter the fishery until the prospective net earnings (revenue minus operating costs) are just balanced by the annual capital costs. The line labeled I_1 in Fig. 1 represents a level of capital cost that implies an eventual fleet size of N_1. If capital costs are at the lower level represented by the line I_2, the fleet will expand further to N_2. When the number of vessels reaches N^{**}, both quotas will be taken in a full fishing year. And further expansion of the fleet beyond N^{**} causes all vessels to remain idle for the remainder of the year. Clearly, this simple model could be expanded to allow for a third or fourth fishery which would be entered successively as the fleet grows and fishing seasons for the more profitable stocks become shorter and shorter.

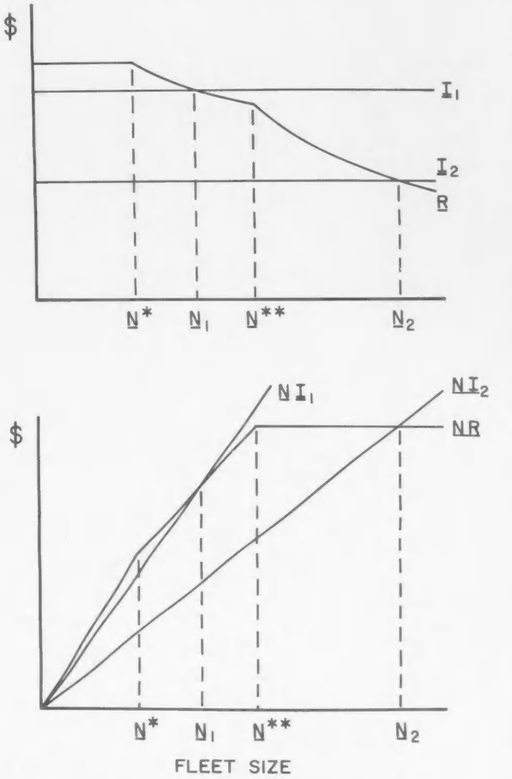

FIG. 1. Theoretical relationship between fleet size (N) and net earnings per vessel (*lower panel*), and between fleet size and total profits (*upper panel*), for two stocks of fish.

The economically rational fleet size depends upon the total net earnings of the fleet and the total commitment of capital. The relevant diagram for this examination is in the lower panel of Fig. 1. The curve labeled NR represents the total fleet earnings in excess of operating costs, and the two lines NI_1 and NI_2 represent the total capital costs corresponding to per vessel capital costs I_1 and I_2. The maximum net earnings of the fleet in excess of capital costs occurs at the fleet size that obtains the greatest vertical distance between NR and NI. For capital cost I_1 the optimum fleet size is N^*, a fleet just large enough to fully exploit the more profitable stock. With the lower capital cost, NI_2, the optimum fleet, N^{**}, is just large enough to take both of the quotas. The simple logic of this is that an economically rational management program cannot allow the fleet to expand further after the incremental increase in capital cost exceeds the incremental increase in net earnings.

Suppose the management program begins to seek economic efficiency only after the fishery has already reached the free-access equilibrium fleet size. If the capital cost curve NI_1 applies, then the fleet size will be N_1, and an excess number of vessels, equal to N_1 minus N^*, will be already in the fishery. Unless the vessels can be transferred into an alternative, underdeveloped fishery, however, it will not be desirable to initiate a licensing program for only N^* vessels. Unlicensed vessels either will go bankrupt or will suffer a capital loss. A similar conclusion holds if the capital cost per vessel is I_2.

In the fully developed free-access fishery it will be apparent that vessels must participate in more than one fishery to earn a satisfactory return on investment. But it is also clear that the fleet may not need to be multipurpose if it were not overbuilt. This is certainly the case if the two fisheries are not seasonal. The vessels become multipurpose only after the fleet is larger than necessary to fish stock 1. With capital cost I_1, the fleet need be no larger than N^*, and no vessels need to shift into stock 2. With capital cost I_2 the fleet needs to be no larger than N^{**}, and the manager can create two separate fleets that specialize on the two stocks. Thus, without seasonality in the fisheries, none of the reasons for diversification identified by Meany (1977) exist. By licensing two separate fleets, the management program can ensure that each fishing season is as long as possible, thus decreasing the costs of processing and storage facilities onshore.

If the two stocks have natural seasons, however, and the capital cost is low enough to justify full exploitation of both quotas, the manager may as well license all of the N^{**} vessels to fish both stocks. This is true at any rate if the cost of building an optimum size multipurpose fleet does not exceed the cost of building two specialized fleets. With a multipurpose fleet, none of the vessels will be forced to spend part of the year in idleness. Thus, the economic rationality of multipurpose fleet with fixed prices, costs, and annual quotas depends upon whether the fish stocks are seasonally available and whether the cost of building multipurpose capability into the vessels is excessive.

The main management implications to be gleaned from the fixed quota model are summarized as follows:

1) A multipurpose fleet is economically efficient if it is just large enough to fully exploit all stocks that yield sufficient net revenue to cover capital costs on an annual basis.

2) If the two stocks can support separate fishing fleets by virtue of year-around availability of fish, then it may be preferable to maintain two distinct fleets through regulation. It should also be recognized that all vessels licensed to fish only for the less profitable stock will be unhappy with this circumstance.

3) If only one stock is profitable enough to support a separate fleet in specialized fishing, then it is economically optimal to have a fleet just large enough to fully exploit one stock. This may appear wasteful or

paradoxical to those who wish to see every fish stock fully utilized.

4) If the fisheries must occur during separate seasons and if it is reasonably inexpensive to outfit vessels for multipurpose operation, then the fleet should be licensed to fish both stocks. Since the full utilization of one of the quotas is likely to require fewer vessels than the other, the multipurpose fleet will have excess fishing capability. But if economic conditions dictate that both stock quotas be fully utilized, the appearance of excess capability is not wasteful.

Under the conditions of the two-stock, fixed quota model, there are only two reasons for having a multipurpose fleet rather than one or two specialized fleets. First, a multipurpose fleet is more economical when the fisheries are naturally seasonal in character. And second, economic rationalization of an already overcapitalized fleet may allow for continued operation of multipurpose vessels to maintain their economic viability as private businesses. This second rationale is not a long-term policy, but rather a condition to be countenanced during a transitional period. The length of the transitional period depends upon the life of the capital equipment in the fishery. As vessels depreciate to the point of nonprofitability, they should be retired.

CASE II — VARIABLE ANNUAL QUOTAS

Environmental influences can cause uncontrolled variations in stock sizes which in turn elicit annual variations in catch rates and quotas. Assuming that prices and fishing costs are fixed, the variations in catch rates translate directly into variations in net revenue earned per day of fishing. The relative profitabilities of two stocks will switch occasionally. Thus each of the following four circumstances may occur in some years: (1) each stock yields some positive net revenue to fishermen, (2) neither stock yields net revenue, (3) fish stock 1 is sufficiently abundant to yield net revenue but stock 2 is not, and (4) fish stock 2 yields net revenue but stock 1 does not. Since neither of the stocks can be relied upon to support a fishing fleet every year, it is natural to suspect that a multipurpose fleet would be more profitable than two specialized fleets.

To illustrate how the optimum fleet size may be affected by variability of quotas and catch rates, I have developed a numerical example the pertinent characteristics of which are listed in Table 1. It is assumed that each stock has five possible annual quotas that occur with known frequencies. One tenth of the time, for instance, the annual quota for stock 1 is zero; 24% of the time the quota is 10 000; 32% of the time the quota is 20 000; and so forth. Similar conditions are specified for stock 2. Fish from stock 1 are sold for a price of $10, while fish from stock 2 bring a price of $20. A day of fishing is assumed to cost $70/d regardless of which stock is being fished.

To complete the example, I assume that each vessel is able to fish 200 d/yr and that the annual capital cost per vessel is $8 thousand. Given the relative frequencies and net daily earnings corresponding to the various quotas listed in Table 1, the expected annual net revenue per vessel and expected annual fleet profits can be computed for any given fleet size. The computations were performed for each stock assuming that no vessels are allowed to change fisheries. Table 2 summarizes the results.

If the two stocks of fish are to be harvested by two separate fleets, then expected net earnings before capital cost per vessel falls in each fishery as fleet size increases. This relationship is comparable to that derived in Case I for a fixed annual quota. As indicated in Table 2, the average net annual earnings per vessel falls to about $8 thousand when each fleet expands to 14 vessels. Thus

TABLE 1. Characteristics of the 2-stock multipurpose fleet model with variable annual quotas and catch rates.

	Quota	Catch rate	Relative frequency	Net revenue/d fishing
Stock 1	0	10.0	0.1	—
	10 000	12.5	0.24	55
	20 000	15.0	0.32	80
	30 000	17.5	0.24	105
	40 000	20.0	0.1	130
Stock 2	0	15.0	0.1	—
	20 000	22.5	0.24	42.5
	40 000	30.0	0.32	80.0
	60 000	37.5	0.24	117.5
	80 000	45.0	0.1	155.0

TABLE 2. Relationship between expected annual profits and fleet size for two separate fishing fleets.

	Stock 1		Stock 2	
Fleet size (N)	Vessel net earnings (R)	Fleet profits (NR)	Vessel net earnings (R)	Fleet profits (NR)
4	15.4	29.6	15.9	31.6
5	14.9	34.8	15.7	38.6
6	14.7	40.0	15.5	44.7
7	14.2	43.1[a]	15.0	48.8[a]
8	13.2	41.9	14.1	48.6
9	12.3	38.9	12.8	43.4
10	11.3	33.5	11.5	35.4
11	10.3	25.5	10.5	27.4
12	9.5	17.5	9.6	19.4
13	8.7	9.5	8.9	11.4
14[b]	8.1	1.5	8.2	3.4
15	7.6	−6.5	7.7	−4.6

[a] Maximum expected fleet profits.

[b] Maximum fleet size which returns, on the average, the annual capital costs.

a free access fishery might stabilize at 14 vessels per fishery, or 28 vessels overall. I say might because vessel owners will not necessarily evaluate the probabilities of earnings the way that an "objective" fishery manager does. Defining an optimum fleet as one that maximizes the expected annual profit earned, the optimum fleet size for stock 1 is seven, and for stock 2 is seven. The aggregate profit earned on the average from both stocks is $91.9 thousand and is generated by a total fleet of 14 vessels.

To investigate the economic consequences of the alternative policy of allowing vessels to shift from one stock to the other whenever profitable, the probabilities of encountering combinations of stock quotas must be specified. Three alternative bivariate relative frequency (or probability) distributions are introduced for this purpose. The first assumes statistical independence of the two stocks. This requires that the probability of encountering any given combination of two quotas be equal to the product of the probabilities of each quota. Thus the probability that both quotas will be zero in any year is $0.1 \times 0.1 = 0.01$. By constructing the joint probabilities in this fashion, the marginal probability of any single quota is the same as specified for the separate quotas in Table 1. Comparability of the multipurpose and specialized fleet examples is thus preserved.

It is assumed that each vessel fishes the more profitable stock until the quota is reached. If the other stock is also profitable, then each vessel switches fishing modes and continues fishing until either (1) 200 d of fishing accumulate, or (2) the second quota is reached. The expected annual net revenue per vessel is calculated by multiplying each of the 25 possible net revenues by the corresponding probability from the joint probability matrix. Expected annual profit equals the expected net revenue minus the capital cost. Additional details regarding the computation of expected net revenue, including a listing of the probability matrix, are in the Appendix. The results of the expected value computations are displayed in Table 3.

The optimum fleet size for statistically independent stocks is 13 vessels. The corresponding fleet profit is $105 thousand. In comparison to separate fleets, the multipurpose fleet is smaller, thus saving capital costs, and achieves a greater average net revenue per vessel. This result depends upon the fact that multipurpose vessels can fish stock 2 when stock 1 is low, and stock 1 when stock 2 is low. It should be expected, therefore, that the economic advantage of multipurpose vessels should depend upon the assumed relationship between the two stocks. If the two stocks are negatively correlated, there should be greater opportunity to shift from stock to stock. If the two stocks are positively correlated, less economic advantage will be enjoyed because when one quota is large the other is also likely to be large.

TABLE 3. Relationship between multipurpose fleet size and annual profits earned from the fishery.

Fleet size (N)	Annual fleet profits with: Independent stocks	Negatively correlated stocks	Positively correlated stocks
	(1000's)		
4	48	52	43
6	71	78	63
8	91	101	80
10	101	112	90
11	103	114	93
12	104.7	114.9[a]	96
13	105.3[a]	114.6	98.1
14	104.0	111	98.4[a]
15	102	107	97.6
16	98	100	95

[a] Profit maximum.

The expected annual fleet profits with positive and negative correlation between stocks are listed in columns 4 and 5 of Table 3. The optimum fleet size is smaller when stocks are negatively correlated, just as expected, and the multipurpose fleet is more profitable. With positive correlation between stocks a larger fleet is required to maximize profits, but, perhaps surprisingly, the multipurpose fleet is still more profitable than separate fleets. In general, therefore, the greater the negative correlation between stocks, the more attractive is the use of a multipurpose fleet.

If the price of fish from stock 2 in the numerical example is reduced from $5 to $3, then the expected annual net return from a separate fishery on stock 2 becomes negative. In this situation it is not possible to maintain a separate fleet for stock 2, but it is still useful to allow the fleet fishing stock 1 to fish for stock 2. With the lower price for stock 2, the optimum fleet for a separate stock 1 fishery is 7 vessels yielding an average of $43 thousand in profits annually. In contrast, a multipurpose fleet would be 9 vessels with an aggregate expected profit of $58 thousand. It is conceivable that a fleet could thrive on a group of fluctuating stocks, no one of which yields a positive expected annual profit. Limited entry for a single stock under such conditions would be inappropriate, because no specialized fleet would be economically viable.

Other important considerations not introduced in the example are (1) the cost of specialized gear and/or the cost of shifting from one stock to the other, (2) enforcement or monitoring costs associated with multipurpose fleets, and (3) the economic loss associated with shorter fishing seasons under multipurpose fleets. Any one of these three could, upon incorporation in the analysis of optimum fleet size, reverse the decision in favor of multipurpose fleets. In the numerical example, the multipurpose fleet was expected to earn $14.1 thousand more in annual profits than could separate, specialized fleets when the stocks are statistically independent. If it costs more than $14.1 thousand to outfit 14 vessels for multipurpose fishing rather than for specialized fishing, then specialized fishing is preferable. Also, it is conceivable that enforcement of regulations, when vessels shift from stock to stock during a year, could be more expensive or cumbersome than when vessels are specialized. If enforcement costs are to be considered in the design of management programs, separation of vessels into specialized fleets may be economically desirable. Before this conclusion is reached for any specific case, hard data and analysis should demonstrate that enforcement costs with multipurpose fleets exceed benefits. Simple administrative ease should not be taken as a compelling case for separate licensing by species or by geographical area.

As noted in the discussion of the fixed annual quotas, fishing seasons may be longer with specialized fleets than with a multipurpose fleet. This would be true if the multipurpose vessels deploy solely on the more profitable species first and then shift to less profitable species. In some cases (salmon runs being one example), the time period over which the fish are available to the fleet may be very short in any case. Nevertheless, some fisheries can be unnecessarily forced into a short time span by the operation of a multipurpose fleet. An examination of the processing and storage costs should serve to determine whether these costs exceed the potential benefits of multipurpose fleet operation.

Management implications of the variable annual quota model are

1) Multipurpose fleets are an economically rational response to economic and environmental variability. The ability to shift from species to species is beneficial to vessel owners and can be important to the economic optimization of a fishery.

2) Since profits per vessel fluctuate, any fees charged to inhibit entry or to extract rents for the public treasury should be flexible. Annual license fees, for instance, should not be fixed at a level that causes hardship to vessel owners in years of poor fishing. Large fixed fees could be replaced by landings taxes or royalties that fluctuate with the fishery.

3) With multipurpose fleet management, there will be apparent excess effort for at least one of the stocks in most years and excess effort for all stocks together in some years. Management of harvest rates must rely upon annual quotas or some other control besides fleet size. Limited access simply provides some long-run average control over effort.

This last point is of particular interest because it suggests the real problems that will crop up in any attempt to identify overcapitalized fisheries or to measure the degree of overcapitalization. Examination of economic data from 1 or a few years may be insufficient to determine whether overcapitalization has occurred. As a corollary, rapid changes in limited entry policies are unlikely to be correctly evaluated. None of this, however, weakens the basic conclusion that free-access fisheries will tend to overinvest in vessels and gear, and that economic efficiency will occur only under a management scheme that limits investment.

Conclusions

Several implications for economically rational control of mixed stocks and multipurpose fleets were developed. It was concluded that mixed stock management requires that individual species objectives be abandoned in favor of aggregate yield objectives. Optimum harvest rates must be developed with full accounting of the revenue and cost effects on all species being harvested. Regulation of fishing methods or gear will influence the relative harvest rates of two or more mixed stocks. Thus, incentives such as differential landings taxes, or standards such as gear or area restrictions may appear prominantly in the list of regulatory tools for mixed stock management. Although it is suspected that a multispecies management approach will largely avoid the creation of "incidental catch problems," it is difficult to reach any general conclusions. More detailed investigation of specific cases will undoubtedly reveal conditions under which combinations of regulatory controls will be optimal.

Multipurpose vessels are shown to be a reasonable response to variations in underlying biological or economic conditions. A vessel capable of fishing in several discrete fisheries is like a diversified portfolio; it is exposed to less financial risk. Furthermore, when two or more fluctuating fish stocks can be harvested by a common fleet, economic efficiency may require that the fleet be managed as a multipurpose fleet. Specialized fleets are efficient with stable, year-round fisheries, but few fisheries fit this description. Thus, the presumption is that license limitation on a species-by-species basis is to be avoided. As a consequence, short-term regulation of harvest rates must be achieved by more flexible methods such as landings taxes, quotas, season or area closures. Management of investment in fleet capacity simply provides the necessary long-term control over capital costs.

Both the biological and economic conditions underlying multispecies fisheries present vast problems for future research. Ecological models for fishery management may need to specify more precisely the effects of predator–prey linkages or competition for food among stocks. An alternative approach suggested by Dickie (1973) is to develop more aggregated models that emphasize harvesting fish of a given size or at a given trophic level rather than individual species. Economic analyses required to make a multispecies model operational include studies of market pricing, processing requirements and costs, gear flexibility, and fishing cost functions. Although it suggests some important concepts for management, the multipurpose fleet analysis developed above must be considered provisional and incomplete. Clearly, many vessels operate in several fisheries; it will be difficult in practice to isolate a fixed fleet of vessels fishing a closed set of stocks. Because of differences in cost, varying seasonal and market conditions, and discontinuities in stock abundances, the appropriate grouping of species will be different at different times and places. Extension of the multipurpose fishery model to include complex overlapping species groups may prove useful. It is hoped that this paper encourages further research along these lines.

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Appendix

The following notation is adopted for the model:

P_1, P_2	Market prices for the two species.
C_1, C_2	Daily fishing costs per vessel when fishing for species 1 and species 2.
T	Amount of fishing time per year per vessel (e.g. 200 d).
I	Annual capital cost per vessel.
t_1, t_2	Number of days that vessels fish for species 1 and 2, respectively (note: $t_1 + t_2 \le T$).
Q_1, Q_2	Annual quotas for the two species.
X_1, X_2	Daily catch rates for species 1 and 2.
N	Number of multipurpose vessels in the fleet.

The net daily operating revenue per vessel in each fishery is

$$r_i = (P_iX_i - C_i), \quad \text{for} \quad i = 1 \text{ or } 2. \tag{1}$$

Annual net operating revenue per vessel is

$$R = r_1t_1 + r_2t_2; \tag{2}$$

and the annual profit per vessel is simply net revenue minus annual capital cost, i.e.

$$\pi = R - I. \tag{3}$$

Quotas are enforced by season closures. Thus the maximum amount of time that a fishing season can be open is determined by the prevailing catch rate and fleet size as follows.

$$t_i^* = Q_i/(NX_i) \tag{4}$$

The term, NX_i, represents the total daily rate of withdrawal from stock i when the fleet is fishing. This rate of catch, divided into the annual quota, determines the length of the open fishing season. Clearly, the more vessels fishing, the shorter the season will be.

FIXED ANNUAL QUOTAS

If there are no natural seasonal variations in fish availability, profit-maximizing vessel operators will fish solely in the most profitable fishery as much of the time as possible. If the fleet size is greater than (Q_1/X_1T), however, the season for species 1 closes before the vessels have exhausted their fishing capabilities. If the fleet size is greater than (Q_1/X_1T) but less than $(Q_1/X_1T) + (Q_2/X_2T)$, the vessels will be fully utilized in fishing first for species 1 and then for species 2. If the fleet is greater than $(Q_1/X_1T) + (Q_2/X_2T)$, both fishing seasons will be closed and the vessels will be idle part of the year. Annual net revenue per vessel is a function of fleet size:

$$R = \begin{cases} r_1T & \text{if} \quad N \le Q_1/X_1T \\ r_1\dfrac{Q_1}{X_1N} + r_2\left(T - \dfrac{Q_1}{X_1N}\right) & \text{if} \\ & \dfrac{Q_1}{X_1T} < N < \dfrac{Q_1}{X_1T} + \dfrac{Q_2}{X_2T} \\ r_1\dfrac{Q_1}{X_1N} + r_2\dfrac{Q_2}{X_2N} & \text{if} \quad N > \dfrac{Q_1}{X_1T} + \dfrac{Q_2}{X_2T} \end{cases} \tag{5}$$

If the two fish stocks are naturally available in two discrete periods of the year (T_1 and T_2), each vessel will seek to fish in both fisheries as much time as possible. Net revenue per vessel is, again, a function of fleet size in three discrete segments. Assuming that stock 1 is the first to be fully exploited,

$$R = \begin{cases} r_1T_1 + r_2T_2 & \text{if} \quad N \le \dfrac{Q_1}{X_1T_1}, \quad N \le \dfrac{Q_2}{X_2T_2} \\ r_1\dfrac{Q_1}{X_1N} + r_2T_2 & \text{if} \quad N > \dfrac{Q_1}{X_1T_1}, \quad N \le \dfrac{Q_2}{X_2T_2} \\ r_2\dfrac{Q_1}{X_1N} + r_2\dfrac{Q_2}{X_2N} & \text{if} \quad N > \dfrac{Q_1}{X_1T_1}, \quad N > \dfrac{Q_2}{X_2T_2} \end{cases} \tag{6}$$

These two equations correspond to curve R in Fig. 1.

Regardless of whether equation (5) or (6) is the appropriate net revenue function, the fleet's total profit is expressed as

$$V = N \cdot (R - I). \tag{7}$$

Assuming that both fisheries yield net revenue ($r_1, r_2 > 0$), the fleet size maximizing V is easily found. If $(r_1T - I)$ is greater than zero for the nonseasonal fishery, then total profit is increased by expanding the fleet up to $N^* = (Q_1/X_1T)$. If the second stock is also profitable, i.e. $(r_2T - I) > 0$, then the fleet should be expanded to $N^{**} = (Q_1/X_1T) + (Q_2/X_2T)$. Any further expansion of the fleet would increase the investment cost but not the net revenue, thus decreasing the profits.

For the case of consecutive natural seasons, if $(r_1T_1 + r_2T_2) > 0$, profits are increased as the fleet expands up to size $N^* = (Q_1/X_1T)$. When the second stock is profitable, i.e. $(r_2T - I) > 0$, the total profit continues to increase until $N^{**} = (Q_2/X_2T_2)$. Expansion of the fleet beyond the size needed to fully exploit the second stock causes a reduction in profits.

VARIABLE ANNUAL QUOTAS

The numerical example in the text is based upon the algebraic model developed above and the following specific assumptions:

(1) $P_1 = 10, P_2 = 20$;
(2) $C_1 = C_2 = 70$;
(3) $I = 8000$;
(4) $T = 200$ d;
(5) $X_{1j} = 10 + .00025\ Q_{1j}, X_{1j} = 15 + .000375\ Q_{2j}$.

where X_{1j} is the daily catch rate for stock 1 with annual quota level j.

The annual quotas have probability distributions listed in Table 1 of the main text.

Letting f_j represent the probability of quota level j, the expected value of net earnings for a vessel fishing solely stock i is

$$(8) \qquad E(R) = \sum_j f_j T^* r_{ij},$$

where $T^* = T$ for $N \leq Q_{ij}/X_{ij}T$,

and $T^* = Q_{ij}/X_{ij}$ for $N > Q_{ij}/X_{ij}T$.

This formula was used to compute the expected vessel earnings in columns 2 and 4 of Table 2. Fleet profits, columns 3 and 5 of Table 2, are simply $N \cdot (E(R) - I)$.

TABLE 4. Joint probability distribution for two stock quotas. Correlation coefficient = −0.53.

	Quota 1				
Quota 2	0	10 000	20 000	30 000	40 000
0	0.00	0.01	0.03	0.04	0.02
20 000	0.01	0.02	0.05	0.12	0.04
40 000	0.03	0.05	0.16	0.05	0.03
60 000	0.04	0.12	0.05	0.02	0.01
80 000	0.02	0.04	0.03	0.01	0.00

In extending the example to multipurpose vessels, it is assumed that each vessel fishes whichever stock is most profitable until the quota is reached. Once the first quota is reached, the fleet shifts to the less profitable stock. Letting f_{jk} represent the probability that quota level j for stock 1 and quota level k for stock 2 will occur in the same year, the expected net revenue is calculated as follows:

$$(9) \qquad E(R) = \sum_{j=1}^{5} \sum_{k=1}^{5} f_{jk}[T_1^* r_{1j} + T_2^* r_{2k}]$$

where

$$\text{(a)} \quad \left.\begin{aligned} T_1^* &= T \\ T_2^* &= 0 \end{aligned}\right\} \text{ for } N \leq (Q_{1j}/X_{1j}T)$$

$$\text{(b)} \quad \left.\begin{aligned} T_1^* &= Q_{1j}X_{1j} \\ T_2^* &= (T - T_1^*) \end{aligned}\right\} \text{ for } (Q_{1j}/X_{1j}T) < N < (Q_{1j}/X_{1j}T) + (Q_{2k}/X_{2k}T)$$

$$\text{(c)} \quad \left.\begin{aligned} T_1^* &= Q_{1j}/X_{1j} \\ T_2^* &= Q_{2k}/X_{2k} \end{aligned}\right\} \text{ for } N > (Q_{1j}/X_{1j}T) + (Q_{2k}/X_{2k}T)$$

To permit comparison of the results for different kinds of stock interactions, equation (9) was evaluated over the range of fleet sizes from 4 to 15 vessels and for three different joint probability distributions. The first distribution representing independent stocks follows the rule that Prob (X,Y) = Prob (X) Prob (Y) for X and Y independent. Probabilities for each quota level are the same as those given in Table 1. Competitive stocks are represented by the probability distribution in Table 4, having a negative correlation of −0.53. The joint probability distribution with positive correlation is created by rotating the probability matrix in Table 4 one-quarter turn.

Fisherman Behavior and the Design of Efficient Fisheries Regulation Programs[1]

JAMES E. WILEN

Institute for Environmental Studies, University of Washington, Seattle, WA 98195, USA

WILEN, J. E. 1979. Fisherman behavior and the design of efficient fisheries regulation programs. J. Fish. Res. Board Can. 36: 855–858.

This paper examines the importance of hypotheses about fisherman behavior for predicting, understanding, and designing efficient fisheries regulation programs. Particular attention is paid to flexible technology fisheries where individuals are free to alter several dimensions of effort. It is suggested that the appropriate hypothesis of share-focused behavior ensures that there will always be an incentive to combine inputs inefficiently although technical conditions may limit or block the actual ability to do so. Some observations on the success of existing programs are also offered.

Key words: fisheries regulation, efficiency, behavior, fishing industry

WILEN, J. E. 1979. Fisherman behavior and the design of efficient fisheries regulation programs. J. Fish. Res. Board Can. 36: 855–858.

L'auteur examine dans le présent article l'importance d'hypothèses relatives au comportement des pêcheurs quand il s'agit de prédire, comprendre et concevoir des programmes efficaces de contrôle des pêches. Il insiste particulièrement sur les pêcheries à technologie flexible dans lesquelles les individus peuvent en toute liberté modifier plusieurs dimensions de l'effort. D'après lui, l'hypothèse du comportement axé sur la part ne fait qu'inciter à une combinaison inefficace d'apports, bien que les conditions techniques puissent limiter ou bloquer la capacité de le faire. L'auteur fait aussi quelques observations sur le succès des programmes existants.

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Individual Behavior and Fisheries Regulation

The ideal situation for policy makers contemplating alternative regulatory programs is one in which policy outcomes are predictable — either because similar schemes have been tried in the past, or, in the absence of experience, because simple logic allows insight into the potential effects of some as yet untried policies. In the case of fisheries regulation policy, we unfortunately have the worst of two worlds — few cases to study in retrospect, and few predictions from social scientists about potential results in untried circumstances. We do have a few studies (Christy and Scott (1965); Crutchfield and Zellner (1961); Crutchfield (1965); Crutchfield and Pontecorvo (1969); Pearse (1971)) of individual fisheries in overcapacity states or in transition from common property to regulation in one way or another, but we are missing both in-depth "hindsight reviews" of existing programs and well-developed bodies of economic theory that predict behavior in a wide variety of circumstances. This paper focuses on the latter deficiency.

The first development in the behavioral theory of fisheries economics goes back to the elegant articles by Gordon (1954) and Scott (1955), which pointed out the important notion that an open access fishery will tend to attract an excess and wasteful application of effort. In a paradoxical sense, however, it is perhaps the very elegance and simplicity of these models that has allowed us to understand such an important fundamental proposition and yet miss some equally important observations applicable to regulating real world open access fisheries. The problem is that since these early articles appeared, most fisheries economists have tended to think in terms of simple one-input models in which the input in the fishery is something seemingly well defined (eg. fishermen) or implicitly well defined (eg. "effort"). The implications of such simple models become equally and obviously simple — if open access allows too much effort (or fishermen, or vessels, etc.), then simply limit these factors by taxing or by quotas, etc. As anyone who has worked with data in real fisheries knows, however, the concept of "effort" in most fisheries is excruciatingly nebulous since fishermen are free to choose vessel length, tonnage, engine size, gear type, hull configuration, etc. in an almost limitless way. What this means, of course, is that the policy prescription that falls out of these most basic models may not be as universally applicable as at first thought — we cannot necessarily simply limit "effort"

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(a multidimensional notion) by, say, limiting tonnage or vessel numbers, or numbers of fishermen. With flexibility, fishermen have the option to, and may, in fact, simply readjust other factors in their control to expand effort and subvert any imposed restrictions.

An important set of issues in trying to predict reactions to regulations, then, are questions of what will, in fact, happen when effort is multidimensional and flexible. Questions we might ask, for example, are

i) In comparison with the simple one-input case, what is the extent of multiple input inefficiency? Is it necessarily true that a multiple-input fishery will use too much of all dimensions of effort, or just some? Or, at the other extreme, will there be too many units in such a fishery — each one combining inputs to produce "effort" in the most efficient manner?

ii) If one component of effort is regulated, how will fishermen combine all other dimensions? Will the industry simply dissipate rents by expanding these other components?

iii) What sorts of policies are likely to be the most effective in regulating fisheries where production techniques are highly flexible?

For the most part, these questions have not been satisfactorily addressed in any literature yet. Crucial to answering these questions is the nature of the individual fisherman's behavior, i.e. what motivates his choice of input configurations when he builds a new vessel or modifies an existing one. There seems to be two contending hypotheses. One possibility is what we might call joint-profit focused behavior. To understand this type of possible behavior, it is illustrative to pretend for the moment that we come upon a fishery that has miraculously already been optimized for efficiency, i.e. just the right number of boats, of the right gear types, size, etc. are harvesting and yielding maximum possible resource returns. Suppose that, again for illustration, participating vessel owners are given perpetual "rights" to these returns in the form of an exclusive transferable permit to fish. The reaction of the industry and outside investors to the situation would be fairly simple — the "rights" or licenses would take on values reflecting the resource returns as investors recognized potential excess profits in the industry. The important question is what should happen over time and here is where the crucial nature of behavioral assumptions arise — for if all participants are very wise they will collectively realize that the fleet represents the best technological combination of inputs (by assumption) and thus it will not pay to replace existing vessels with longer or faster boats, etc. Hence efficiency or optimal input use will be sustained as participants behave as if they were explicitly colluding on choice of inputs by focusing on maximizing joint profits.

The above behavioral hypothesis is appealing and if we could be sure that it is reasonable, then our difficulties with designing regulation programs would certainly be fewer. What is implied, for example, is that common property inefficiencies are due solely to there being too many units on the fishery — each producing effort as efficiently as possible. Thus the corrective policy is clear and simple — to improve efficiency we need only ensure that the "right" number of individual decision makers (vessel owners) are participating in the fishery since each one will organize the other inputs in his control in a cost-minimizing way.[2]

Unfortunately, there are some rather serious problems that should make one wary of believing in this hypothesis and its implications. The main difficulty is that it lacks stability, i.e. there is nothing generally that will hold individuals to the efficient input choices that are necessary for them and the group as a whole to benefit the most. Consider, for example, what will happen if one vessel owner decides to make his boat just a little faster and with a bit more hold capacity so that he can arrive at the grounds slightly ahead of the rest of the fleet. If the others don't follow his example, our maverick vessel will gain at the expense of everyone else. If the motivation exists for one vessel, of course, it exists for all of them and yet paradoxically, if all do increase engine and hold size everyone becomes worse off than the initially hypothesized least cost position. The dilemma is nearly symmetrical because if our one vessel does not change while everyone else does then he will lose at the expense of everyone else. Hence participants in a flexible production technology fishery will be, in the manner of a multiperson prisoner's dilemma problem, driven inescapably toward inefficient input configurations even when the "right" number of units is managed.

The above scenario introduces the alternative behavioral hypothesis which we might call individual-share focused behavior, i.e. individual fishermen formulate input configuration decisions based on trying to increase, or at worst maintain, some expected share of the total catch revenues. As yet this type of behavioral hypothesis hasn't been fully explored in the literature and thus the specific choices that might be made in a fishery by participants motivated by such behavior are unclear.[3] However, the ultimate implications are as pointed out above. If vessel owners cannot ensure that their competitors will refrain from making capacity-enlarging changes, then they are more or less forced to do so themselves even though if everyone does, costs simply rise without necessarily increasing revenues. In a catch-regulated fishery (certainly the norm in practice), the sword is double-edged since each cannot rise and if individual vessels do not keep pace with the rest of the industry, they necessarily face declining shares of the catch. The process cannot go on indefinitely, of course, but rather it is driven by perceived share-increasing opportunities and limited by corresponding costs. What is apparent, however, is that in a flexible fishery, any regulation scheme that aims at efficiency by restricting one or a few facets of effort is bound to fail. Vessels will either be too large, or over-powered, or with excess hold capacity, or with redundant multiple units of electronics, or with various combinations of these and other maladies.

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[2] Note that this issue arises only when the fishery is a multiple input fishery since if only one input is used, fishing units are synonymous with inputs used. When multiple inputs are combined to produce effort, a question arises whether common property will result in too many units, or inefficient input configurations on those units, or both.

[3] This is a difficult hypothesis to incorporate and model since it calls for models of *n*-person noncooperative games.

Evidence from Existing Programs

The methods used by researchers to examine scientific problems in medicine, biology, etc. follow a tried-and-tested procedure of hypothesis formulation, empirical testing, and reformulation of hypothesis in light of experimental evidence. In social experiments, including those associated with regulating fisheries, there is certainly no lesser need to carefully review the evidence when formulating basic theories. It is thus instructive in light of the above discussion of what we predict should be happening to examine what is, in fact, happening in the few regulation experiments we do have. A cursory review of the papers in this volume on the B.C. experience (Fraser, Pearse and Wilen), the Alaskan experience (Adasiak), and the Australian experience (Meany), as well as other reviews of other programs indicates that all existing input restriction programs seem to be facing the same problem — namely, an inability to effectively halt the growth of fishing capacity in industries where excess capacity is already the major problem. In each of these cases the evidence is in accord with the previous discussion of share-focused behavior in that while numbers of vessels may have been controlled, total inputs have not been restrained from growing even when catch has been held constant. On the face of it, then, there is some evidence to confirm what share-focused behavior suggests — namely, a continued tendency towards over-capitalization when limits have been placed on one or some inputs.

The remaining question is, is there a limit to this process? That is, will all potential rents be dissipated in schemes that control one or a few inputs or is it possible to achieve some efficiency success? The answer to this question seems partly conceptual and partly empirical. On the conceptual side, if we ascribe to the belief that fishermen are basically share-focused, then the incentive to combine inputs inefficiently is always extant. The ability to do so may be limited technically, however, and that is where the empirical issues arise. If, for example, regulations can "bind up" technical flexibility by limiting a few key dimensions of effort (e.g. length, width, hold capacity, tonnage, horsepower), then quantitative input-focused programs may be successful in limiting redundant input expansion — simply because it eliminates opportunities to alter inputs. Of course, this regulatory design is simply moving closer to complete input restriction. The practical and empirical question is, if we are able to control only a few key dimensions, which dimensions are key and what levels should we choose to restrict these dimensions to?

Relevant to this last practical problem is again the question of what we can discern from current regulatory experience. It has been inferred, for example, that the value of licenses in currently regulated fisheries is an adequate indicator of the efficiency success of (and differences between) such programs. This is certainly plausible but caution should be exercised since the logic is not quite symmetric — efficiency gains if achieved should be capitalized into fixed factors such as licenses, but the existence of positive license values is not necessarily evidence that sustainable efficiency gains are being achieved. There are several circumstances for example, which could give rise to positive license values in a fishery that has dissipated (or will) all rents. Among them are

i) Adjustment lags — rising fish prices may create temporary rents which are currently capitalized due to sluggish investment behavior but which in the future will be completely dissipated in redundant input expansion.

ii) Expectation effects — current price increases may lead to expectations of continued price increases which are then capitalized incorrectly into license values. Alternatively, fishermen may expect future rents due to enhancement programs or entry limitation programs even though their collective behavior will ensure that such rents will not actually be sustained.

iii) Cash-in-hand effects — high, but temporary, windfalls may lead to excess cash which (partly due to investment tax incentives) is reinvested by fishermen in their own vessels or in attempts to increase their individual shares by owning several rather than one boat.

iv) Joint fishery spillovers — in joint fisheries where only one fishery is regulated, the appearance of rents in the unregulated fishery can give rise to positive license values in the regulated industry which will persist as long as expectations of these continued rents persist — even though the regulated fishery has dissipated its own rents.

Any or all of these could give rise to positive license values which might appear to indicate efficiency gains even in a fishery that has, in fact, dissipated its potential rents — through excess and inefficient input configurations.

Conclusion

This paper makes the point that simple one-input models of common property fisheries are not rich enough to provide policy guidelines relevent to modern flexible technology fisheries where effort is multidimensional. It is suggested that an efficient joint profit maximizing configuration of inputs cannot be sustained in a flexible fishery because each individual will underestimate the group costs of altering his input configuration. This is a natural consequence of the behavioral setting of fisheries. Where total catch is limited and divided between many participants, each fisherman will be share conscious and hence driven, as in a prisoner's dilemma game, towards inefficiency and rent dissipation.

If this is, in fact, the case, then a completely new look at regulatory schemes is warranted since, generally speaking, single component effort regulation will not be effective in promoting efficiency. Only when technology is relatively inflexible will it be possible to "bind" input configuration choices by regulating one or a few components of effort. It may not be desirable to place too much faith on these cases either since in a dynamic setting these too will become progressively more difficult to manage. A major problem is that the boat building industry will be under extra incentive to create new designs that increase potential shares within the regulated constraints. But as soon as a successful innovation appears, the regulations will have to be redefined in terms of the new design to keep aggregate capacity from expanding. The process appears to be potentially never-ending. It appears, in fact, that only two approaches can be effective: either explicitly regulating all key facets of effort (usually administratively difficult) or designing systems that produce the incentive to combine inputs in the least-cost manner permitted by technology. As an example of the latter, suppose that instead of licensing tonnage or fishermen, authorities gave each vessel a license to catch a fixed quota or share of fish. Then it would be in each owner's interest to try to catch those fish in the least-cost way — necessitating efficient input combination. The difference in this case is that the system design produces desirable behavior — the incentive to fish efficiently — because the motivation for share focused behavior is removed by the design itself. Variants of the system could be designed to permit flexibility and to achieve other goals, of course. The important point is that it is possible to remove the cause of inefficiency (the behavioral motivation for share-focusing) rather than attacking the symptoms by appropriate choice of regulating design.

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Quantitative Rights as an Instrument for Regulating Commercial Fisheries[1]

DAVID G. MOLONEY AND PETER H. PEARSE

Department of Economics, The University of British Columbia, Vancouver, B.C. V6T 1W5

MOLONEY, D. G., AND P. H. PEARSE. 1979. Quantitative rights as an instrument for regulating commercial fisheries. J. Fish. Res. Board Can. 36: 859–866.

A method of regulating commercial fisheries by providing fishing enterprises with transferable rights to harvest specific quantities of fish is described and analyzed in terms of its incentives for economic efficiency in harvesting, its administrative practicability, and its amenability to alternative objectives with respect to the division of resource rents between fishermen and the government. The regime proposed can, under certain realistic conditions, be expected to maximize resource rents and to permit the gains to be distributed flexibly. This approach is found to have certain superior characteristics over the main alternative proposals for rationalizing fishing.

Key words: quantitative rights, fishermen's quotas, stinting, economic rationalization, licensing, regulation

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Nous décrivons une méthode de controle des pêches commerciales selon laquelle les entreprises de pêche reçoivent des permis transférables les autorisant à récolter des quantités spécifiques de poisson. Nous analysons cette méthode en fonction de son stimulant à une efficacité économique de récolte, sa facilité d'administration et la façon dont elle se prête à un choix d'options quant au partage, entre pêcheurs et gouvernment, des loyers de la ressource. On peut s'attendre que, dans certaines conditions réalistes, le régime pourra porter au maximum les loyers de la ressource et permettre une certaine souplesse dans la répartition des gains. Cette approche a certains avantages sur les autres options proposées dans le but de rationaliser la pêche.

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As the papers collected in this volume show, a good deal of attention is now being focused on alternative policy instruments for mitigating the economic inefficiency and waste usually associated with common-property exploitation of fisheries. The academic literature on this subject is already extensive.[2] Only recently, however, have the governments of Canada and some other western fishing nations begun to demonstrate both an understanding of the problem and a determination to improve the economic performance of commercial fisheries. Tentative regulatory measures, some of which are described in preceding papers, are being put in place. This political action, related to the recent revolution in world fisheries jurisdictions, has stimulated new interest on the part of both public administrators and academic economists.

At the Powell River symposium, where most of the other papers in this collection were presented, the merits and limitations of traditional controls on fishing as well as relatively new ideas involving fiscal devices and restrictive licensing, were extensively discussed. In addition, considerable interest was sparked by the more novel suggestion of some participants that economic efficiency might be promoted most effectively by providing individual fishing enterprises with rights to harvest specific quantities of fish. Although this general approach is common in the institutional arrangements governing the use of many other natural resources, it has not hitherto received much attention in the fisheries literature. This, coupled with the obvious break with the traditional rule of capture that this approach implies, hindered a clear comprehension of how such a regime might work and how its alleged results would be realized. The purpose of this paper is therefore to describe how a system of quantitative rights might be designed and to explain its implications for economic efficiency in the fishing industry.

The paper begins, in the next section, with a brief discussion of the extent to which the economic performance of the fisheries hinges on the nature of the

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[1] This paper was written after the symposium at which most of the other papers in this volume were presented.

[2] One of the earliest and most comprehensive economic analyses of alternative regulatory techniques is that of Scott (1962). A. Scott's paper in this volume and that of J. Crutchfield review the literature on this subject.

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property rights held by fishermen. This is followed by a description of how a regime of quantitative rights might be implemented, and an explanation of how it would promote economic efficiency. These implications are compared with those that could be expected under the alternative regulatory device of royalties or taxes on the catch. The final section examines some qualifications and modifications that might be called for to meet special circumstances in practice.

The Problem

The basic economic problem to be addressed is the persistent and inevitable tendency of fishing fleets, whenever they are composed of large numbers of independent enterprises competing for the available catch, to expand redundantly as long as the fishery yields positive net returns. This process is well explained elsewhere, readily observable, and widely acknowledged. The result is that whether stocks are depleted or not, and whether the fishery settles at a "bionomic equilibrium" or is held at some regulated level of catch, all potential resource rents become dissipated in higher costs through employment of unproductive labor and capital. The policy issue is thus to find ways of containing this wasteful expansion, or of removing the incentives that cause it.

The problem is clearly rooted in the nature of the property rights held by the resource users. Apart from some of the writings of institutional economists, especially those dealing with agriculture, the economic theory of property rights has not received much attention. The simplistic distinction between private property and public ownership common in the literature ignores the wide range of property forms that economic agents use in practice, and particularly those applicable to natural resources. In this field, the archetypical "fee simple" seldom, if ever, applies because legislatures have cut away many of its common law attributes, applied taxes and controls on use, and otherwise truncated the bundle of rights traditionally implied by this form. Land and resources in public ownership are exploited largely by private enterprises under a bewildering assortment of leases, licenses, permits and other contractual arrangements.

Within this variety of property systems is a group classed somewhat imprecisely as common property, meaning, generally, that two or more parties claim rights to exploit the same resource jointly. However, this group includes a range of types varying in terms of the exclusivity of the rights claimed. At one extreme, access is unrestricted and the share of the resource available to each participant is unlimited, which is the case for many public facilities and resources such as recreational areas as well as traditional fisheries. The next group is those for which access is restricted in some way but again the users' shares are not. Thus the use of a resource is often reserved to parties that meet some qualification or who hold a license, as in the case of oil reservoirs exploited by the holders of surface rights, and (recently) fisheries subject to restrictive licensing, where the rule of capture nevertheless obtains. More exclusive still is the arrangement in which the users are not only limited, but also their rights are stinted (to use the medieval term referring to the allocation among commoners of rights to graze specific numbers of livestock on the feudal commons). Examples include quota rights to use rangelands, "unitized" oil and gas reservoirs, timber rights that convey an "allowable annual cut", water-taking licenses along watercourses, and many others. It is the addition of this stinting principle to fisheries that are already regulated under some form of restricted access, but in which fishermen compete for their catch shares (the usual situation today in the commercial fisheries of Canada), that is to be examined here.

A variety of theoretical discussions touch on the economic implications of quantitative property rights, many in the literature on pollution. The well-known work of Coase (1960) and Smith (1974) both demonstrate that when one party inflicts a negative externality on another, a socially optimal outcome will result if the victim is in a position to sell rights to produce the externality to the producer. This is akin to the fisheries problem insofar as the taking of fish by one fisherman inflicts an externality on others; the problem differs, however, in that the parties involved in the fisheries case are in the same industry and they are not unique pairs of victims and producers of the external effect.

Dales (1968) considers a market in specific rights to discharge pollutants into watercourses and concludes that this would lead to a social optimum, a conclusion that is demonstrated rigorously by Montgomery (1972). Others have discussed the economic advantage of quantitative rights over less specific rights in the context of water resources (Campbell et al. 1974) and oil and gas (Crommelin et al. 1978).

In the fisheries literature, Christy (1973) proposes a scheme that he refers to as "fishermen quotas." However, this has several features that we consider disadvantageous and hence distinguish it from the system described below. One of these is that the quotas are defined as a percentage of the total catch, which would restrict flexibility in their allocation and add to the difficulty of adjusting the catch downward. More important, Christy's quotas are not transferable, although, as we explain below, transferability serves a valuable economic and administrative function.[3] A scheme without these features is discussed briefly in a recent paper by Pearse (1978).

Two contributors to this volume explicitly consider quantitative fishing rights as regulatory devices. J. Crutchfield recognizes certain advantages of such a scheme, but concludes that it must be combined with a tax or fee on landings for optimality to result. In contrast, A. Scott argues that such a system of rights is sufficient to produce a social optimum and that it is simpler and more straightforward than alternative approaches — a conclusion that is consistent with our findings below.

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[3] In a recent paper K. McConnell and V. Norton reject a system of "fishermen's quotas" as inimical to efficiency and unworkable (McConnell and Norton 1978). However, they seem to assume a system of rights that have quite different characteristics from those suggested here.

The question here is limited to the efficacy of institutional arrangements in promoting economic efficiency in the harvesting of prescribed total catches from stocks of fish. We thus leave aside the important but separable issues of determining the optimal catch and the optimal stock size over time.[4] However, it is relevant to note that since these are likely to change, flexibility is an advantageous feature of harvesting controls. Also ignored here are the kinds of regulations required to protect stocks from destructive forms of fishing, such as controls on mesh sizes, protection of spawning areas and so on: these are adjuncts to any prudent resource management policy.

A Quantitative Rights System

To begin with the simplest circumstances, assume a separable, stable fish stock for which the allowable catch is predetermined; a fishing fleet composed of a large number of independent fishing units dependent on it; and a regulatory authority charged with organizing the fishery so that the catch will be harvested with minimum costs of harvesting and administration. The authority might issue rights that authorize the holders to catch specified quantities (numbers, pounds or tons) of fish. These would be freely transferable. They would be denominated in small enough units that a typical fishing enterprise would require many of them to operate efficiently, their small size and large numbers contributing to an active market in rights and hence flexibility in adjustments to the size of individual fishing enterprises. For the time being we assume that the rights are allocated each year or season, although later we argue that perpetual rights offer some advantages without (necessarily) any loss in flexibility.

An important policy question is the method to be used by the regulatory authority for allocating these rights among fishermen. The most obvious solution is an open auction, which would tend to capture the resource rents for the authority and to direct the rights immediately to the most efficient users. Drawing lots would leave the rents to fishermen, but would also add considerable uncertainty. However, in an effort to avoid dislocation and to ensure that existing participants benefit from policy innovations of this sort, governments have almost always chosen to distribute new forms of rights among established enterprises without initial charge (as is documented in the papers by Fraser, Adasiak, and Meany in this issue). Thus the authority might simply allocate the new quantitative rights among the established fishermen in proportion to their shares of the catch over a past qualifying period, and if the fishery is already subject to restrictive licensing the existing rights to engage in fishing could accordingly be converted to rights to take specific quantities of fish. But while the method of initially allocating these rights has important implications for the distribution of benefits, its implications for efficiency are only transitory, because an active market in freely transferable rights will ensure their reallocation to those who can derive the highest value from them in any event. We assume perfectly competitive markets for financial capital, vessels and gear, and harvest rights.

There are few fisheries in which the present level of catch is considered optimal, or are free from biological fluctuations that call for cyclical and even shorter term adjustments in the catch.[5] To permit this flexibility without imposing the financial uncertainty on fishermen that would result from unforeseen compulsory restrictions or adjustments to their harvesting rights, the authority could stand ready to enter the market for rights, buying or selling at the market price in response to changing management requirements. It should be noted that except under special circumstances and trends, this activity would not impose any long-term net financial burden on the regulatory authority.

Fishermens' Behavior and Economic Efficiency

Operating under these circumstances, the individual fisherman would face the problem of maximizing his profits subject to the constraint that his total production must not exceed the number of rights that he holds. The total catch, hence also the price of fish, would be beyond his control. His costs are of two kinds: the usual costs of production which are a function of fishing effort, and the cost of harvesting rights which varies with the quantity held. With the ability to adjust both, he can be expected to do so in light of the marginal revenues and costs associated with each, in search of a harvesting unit of the most efficient size and technology. Thus, in terms of microeconomic theory, he will adjust to the minimum point on his long-run average cost curve, which (since the unit price of rights to him is fixed) is the minimum point of costs including the price of fishing rights. The appendix offers a rigorous proof of this solution.

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[4] These issues are not technically independent insofar as determination of the rent- (or net present worth-) maximizing catch and stock size calls for data on the cost of harvesting (see Appendix). Here, we are concerned only with the problem of promoting efficiency in the harvesting of the available catch, however that is determined.

[5] Others have emphasized the limitations of our models of fish populations, their susceptibility to poorly understood exogenous influences, and hence the need for an adaptable harvesting policy (see, for example, L. Dickie's paper in this volume, and Clark 1978).

The fisherman's behavior thus depends on the price of catch rights, and his choice of optimal scale therefore requires that the price of rights accurately reflect the social value of the resource. At any price, a fisherman will demand or offer rights depending upon whether the net revenue he expects from his catch, at the margin, exceeds or falls short of the price of rights. Competition will provide incentives to minimize factor costs, and by the usual Walrasian tatonnement, supply and demand for rights will tend to yield an equilibrium price which all fishermen will seek to equate with their marginal operating profit.[6]

Market forces can thus be expected to generate an equilibrium price for fish harvesting rights which reflects the full difference between minimum achievable catching costs and the price of the product. The aggregate value of rights held by the fleet should thereby measure the full economic rent attributable to the resource, and their unit price the resource's average and marginal social value.

In short, a system of quantitative rights as depicted above, under the conditions assumed here, would generate economic incentives for optimal organization of the fishery in the sense of cost minimization or rent maximization. All rents would be capitalized in the value of rights (unless they were captured by some fiscal device, as described below). Importantly, the fishery would not be impeded in adopting new technology that reduces real costs, but there would be no incentives to adopt the kind of wasteful technologies associated with competition among fishermen for larger catch shares, which are so conspicuous in unstinted fisheries. Finally, the regime is stable in the face of shifting prices of inputs or products; such changes will simply alter the market-clearing price of inputs.

Stinting vs. Fiscal Controls

Before examining some complications to the simple policy-making environment postulated above, it is instructive to compare, briefly, the efficacy of this quantitative rights approach to economic rationalization of fisheries with the main alternatives. The only alternative with which we have experience in common property commercial fisheries is restrictive licensing of inputs. The practical problem in this method is the choice of the input to be restricted; the number of vessels, or aggregate tonnage of the fleet have been the most common. This experience (such as that documented in the preceding papers by Fraser, Pearse and Wilen, and Meany) supports the numerous theoretical arguments that limitations on one input will, in circumstances where the rule of capture holds, lead to more extensive use of other inputs whenever rents emerge; the only unresolved general question appears to be whether all rents will be dissipated by such substitution (Scott 1962; Wilen, this issue). Because the configuration of inputs in fishing is flexible, this approach can be effective in realizing the full resource rents only if all inputs are simultaneously restricted. But the dimensions of fishing effort are so numerous and complicated that this is practically impossible; and even if it were not, this approach could hardly be responsive to technological change.

Thus much of the recent theoretical literature has focused on fiscal devices — taxes or other charges on inputs and outputs. The general conclusion is that under static conditions, a perfectly adjusted tax either on fishing effort or on the catch can produce an optimal income. The former raises the same problems of specifying effort as does restrictive licensing, and so will not be considered further here. Of greater interest is the relative advantages of a quantitative rights system and one based on a tax or royalty on fish caught, where the rule of capture holds.

It can readily be demonstrated, under the usual assumption that catch is a function of effort and stock size, that a certain royalty on the catch (specifically, the same amount as would emerge as the equilibrium price of catch rights above) would lead to optimality (Anderson et al. 1977; D. G. Moloney unpublished data).[7] But these analyses are somewhat artificial insofar as there is no deterministic relationship, in the sense of a simple functional form, between effort, stock, and catch from the point of view of the fisherman; he is concerned also (if not mainly) about competition from other fishermen. Unlike the case described earlier in which he has a right to take a catch of a specified amount and other fishermen are regulated accordingly, he remains uncertain about his catch. He can control only his effort, and a levy on his catch will not properly regulate his decision-making unless he can accurately predict the marginal product of his effort. Rational fishermen operating under the rule of capture will, to protect their share of the catch, still have incentives to increase their fishing power which, in the aggregate, will prove redundant. To the extent that rent is captured by the tax, it will not be dissipated, but inefficient distortions in fishing effort are likely to prevent the full potential rent from being realized.

We thus argue that the demonstrations of optimality resulting from a perfectly adjusted royalty on the catch have abstracted from an important behavioral element which is likely to spoil their results. But there are practical shortcomings to the royalty approach as well.

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[6] If all factors employed in fishing were homogeneous, this process would lead to fishing units of identical scale and technology, but this tendency may be forstalled if (as is frequently asserted) inputs in fishing vary with respect to their opportunity cost (Pearse 1972).

[7] For a thorough discussion of the parallel problem of regulating pollution through effluent charges see Anderson et al. (1977).

One is the formidable task the authorities would face in determining the required charge, which, if it did not precisely capture all the resource rent, would leave stimuli for wasteful adjustments in fishing effort. But to solve this problem, the authorities would have to accurately calculate cost functions for the potentially most efficient fishing methods.[8] Different rates would be required for fishing grounds with differing costs. Moreover, because any change in input prices, output prices, or technology will shift the fisherman's profit-maximizing level of operations, the levy would have to be continuously revised to meet new circumstances. Such controls could hardly be depended upon where stock fluctuations call for quick and substantial alterations to harvesting plans. This approach thus puts rather unusual technical and econometric demands on the regulatory authority, and calls for a degree of continuous, discriminating adjustment to the levies on catch which probably cannot reasonably be expected of a public agency or regarded as acceptable to fishermen.

Another point of contrast between economic regulation by royalty and by stinting that we consider important has to do with risk-bearing. On the surface, the potential resource rent is the same under either system. But a fisherman holding quantitative rights is assured of his share of the catch or the market value of his rights to take it, and if it turns out that the stock cannot sustain the projected catch, the authority will purchase his rights. Under royalty regulation the fisherman has no assurance of either, and hence bears more risk. Assuming fishermen are averse to risk-bearing, an extra risk premium should be imputed to the costs of fishing where fishermen have no rights to a catch, and hence rents will appear lower.

There are two aspects of this issue. First, the potential economic rent may be less under one regime than another if the institutional arrangements within which it operates inherently generate more uncertainty and risk in the production process. Royalty regulation seems to involve forms of operating risk that do not exist under a rights scheme. Second, the risk may be distributed differently between fishermen and the public authority. As argued in the oil and gas literature, an individual operator bears less of the risk than the government when the revenue system depends on the royalties on whatever is recovered rather than on lump-sum initial payments for rights (Crommelin et al. 1978). However, as we point out later, a quantitative rights scheme for fisheries lends itself to a variety of public levies, including royalties, which can distribute financial risk in almost any desired way.

Finally, and probably much more importantly, a system based on quantitative rights admits flexibility in the distribution of resource rents while one dependent on a levy on output does not. The latter depends on extracting all the rent from fisheries. Yet in all cases we are aware of where governments have intervened to improve the economic performance of fisheries, an important objective has been to raise the chronically low incomes of fishermen. Any regime that precludes fishermen from sharing in resource rents is not likely to be acceptable wherever governments adhere to this redistributive goal.

Qualifications and Complications

We thus see important economic, administrative, and political advantages of the stinting approach over the main alternative regulatory devices. We now turn to consider some modifications to the simple scheme outlined above which may be called in for practice.

TERMS OF RIGHTS

While we have, for expositional convenience, described a system in which the regulatory authority allocates rights annually or seasonally, the same results could be expected from rights that specified a quantity of fish per period but carried longer or even perpetual terms. As long as fishermen had access to competitive financial markets, the only change would be the higher value of a license, which would in this case reflect the present worth of the stream of annual catches expected over the term of the license.[9]

Long-term or perpetual rights offer two obvious advantages. One is administrative simplicity over rights that require annual allocation: indeed, perpetual rights would eliminate the issuing task once for all. The other is that they afford the fisherman a higher degree of financial certainty in his investment planning. If, contrary to the assumption of perfect capital markets, vessels and other real capital can be created, adjusted, or traded only with some lag or at some loss, the ability to acquire rights at a known price for a term as long or longer than the planned life of his physical capital would add considerable to the fisherman's security. The possible disadvantages of long-term rights seem minor, mainly the increased funds required to make adjustments in outstanding rights.

Compromises in the terms of rights are, of course, possible. The authority might, for example, grant basic, long-term, or perpetual rights amounting to less than the total allowable catch even in poor years, the remainder to be auctioned or otherwise allocated each year. This would be an attractive modification if, for administrative or political reasons, purchasing rights off the market were more difficult than selling. Moreover, this arrangement might facilitate rent appropriation and enforcement, as described below.

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[8] More difficult would be the estimation of behavioural reaction functions for fishermen faced with decreased returns. As an alternative to research-based action, the authority could take recourse in trial and error to find the needed royalty level. However, since this is inherently a method of correcting observed errors, it would tend to leave fishing enterprises constantly in a state of uncertainty and readjustment.

[9] The opportunity cost of holding a long-term or perpetual right for one year would therefore be $r \cdot$(present value), where r is the holder's relevant interest rate.

ADDITIONAL SPECIFICATIONS

Some of the problems associated with other regulatory systems will remain in certain fisheries. One of these is the incentive for competitive haste among fishermen where the stock becomes thinned, and hence the cost per unit of catch rises, during the season. This incentive must be regarded as minor compared with the incentive to rush where fishermen's catches are open to pre-emption one from the other, but in some fisheries it may be strong enough, hence potentially wasteful enough, to warrant control. In such cases, the solution would be to specify rights by the part of the season in which they are to be exercised; later rights would thus usually assume a lower value. Similarly, where management required selective controls over several stocks or parts of a stock, rights might be specified with respect to location. These modifications would, of course, complicate enforcement (see below).

Other frequent complications are catches of mixed species, multiple-gear fisheries, and fleets that operate in more than one fishery, as described in D. Huppert's paper (this issue). Generally, vigorous markets for quantitative rights specific to each stock that requires separate management should minimize these administrative difficulties (certainly in comparison to the imposition of differential charges under the catch-tax alternative) and encourage efficient joint-product fishing operations.

More difficult to cope with would be stocks that are subject to fluctuations of such magnitude and unpredictability that they call for very quick changes in fishing activity (such as the Pacific salmon and herring fisheries). Above, it has been argued that an advantage of a quantitative rights scheme is its flexibility and adaptability to changing conditions; but there are almost certainly cases where adjustments through the market for rights would be too slow, and fishing activity must be regulated by fiat. For this reason, quantitative rights would be most easily adapted to fisheries that do not call for frequent, intraseasonal management intervention in the form of changes to the allowable catch.

ENFORCEMENT

It has often been pointed out that the difficulties of enforcing management controls would be aggravated under quantitative rights, because of the incentives to bootleg fish in excess of one's holdings of catch rights (Crutchfield, this issue; P. H. Pearse 1978). Three observations on this problem seem warranted. First, the gravity of the problem will obviously vary depending upon port landing and marketing arrangements, the value of fishing rights, and other circumstances. Second, it should be noted that a similar (albeit weaker) disincentive to report catches is generated under a system that depends on royalties or taxes on the catch. And third, any increased costs of surveillance and enforcement associated with this approach must be seen in light of its general administrative simplicity and economy compared with alternative systems.

Where nonreporting is likely to be problematical, regulatory authorities may find it advantageous to build-in offsetting incentives to report. For example, it was suggested above (for other reasons) that fishing enterprises might be provided with basic rights that amounted to less than the allowable catch, the remainder to be allocated seasonally, perhaps by auction. If these basic rights were subject to some proportional adjustment according to the fisherman's reported catch in the previous season, he would have strong incentives to fully report.

DISTRIBUTION OF RENTS

As already mentioned, free allocation of catch rights would tend to leave fishermen the beneficiaries of any resource rents, to accrue to them as capital gains or as profits from fishing. However, a wide range of fiscal devices present themselves for capturing some or all of this rent by the regulatory authority. An auction in rights would capture all resource rents; a royalty or other levy on landings could be adjusted to capture any desired portion, or a tax (like a property tax applied to other forms of rights) might be applied to the rights directly. The point to be emphasized is that the efficacy of the system will not be prejudiced by such redistributive impositions, nor does it depend on them. Indeed, a system in which rights are quantitatively specified appears to be the only kind that enables this redistributive flexibility. And in view of governments' customary concern to enhance fishermen's incomes, this is a major attraction of the approach.

Conclusion

This paper has, admittedly, a tone of advocacy in favor of "stinting the fisheries." This reflects our concern that, in the current haste to find new fisheries controls, this relatively unexplored (with respect to fisheries) approach will be neglected or forestalled by measures based on more familiar but less effective alternatives. Most of us who have examined the problem of economic rationalization of fisheries would agree that a single method is not likely to be best suited to all fisheries, but we suspect that within the wide range of circumstances and needs, quantitative rights have an important place.[10]

A regulatory system based on rights in the form of privileges to take specific quantities of fish offers a variety of advantages. It is relatively easy to introduce and thereafter to sustain without involuntary dislocation among established fishermen. It permits flexible redistribution of rights through private transactions, and adjustments in the total catch, through intervention in the market for rights by the regulatory authority, without inflicting financial uncertainty on the participants. If necessary, separate rights could be issued to authorize catches of different stocks or parts of stocks, at different seasons or in different areas as biological management requires.

But the appeal of this approach lies mainly in two unique features, one relating to efficiency, the other to distribution. For the first, quantitative rights cut to the basic cause of economic waste in fishing: rights to take specific quantities of fish largely eliminate individual fishermen's incentives to protect and increase their shares of the catch by defensively and competitively increasing their fishing power. For the second, this technique admits full flexibility with respect to the division of resource rents between the government and the participating fishermen.

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Appendix

The purpose of this appendix is to demonstrate more rigourously the optimality of the organization of fishing under a system of quantitative rights.

EFFICIENCY IN HARVESTING

The fisherman may be considered to be a profit-maximizing entrepreneur operating under the constraint that his production must not exceed his holdings of rights. However, he is free to adjust both his catch and his rights portfolio and will do so with reference to the costs and anticipated revenues associated with each type of adjustment.

We adopt a net revenue function $R_i(H_i, X)$ which denotes the flow of net economic benefits to fisherman i from harvest rate H_i, when the stock size is X. Implicit in this formulation is a very general harvest function $H_i = H_i(E_i, X)$ where E_i is the level of effort expended by fisherman i (Clark 1976). This definition of net economic benefit refers to economic rent accruing from the fishing operation itself, and thus excludes costs or revenues arising from purchases or sales of rights.

We assume a large number of atomistic fishing enterprises, each of which must hold a portfolio of rights to participate. These rights (however initially allocated) may be freely bought and sold at a price m, determined by the equilibrating forces of supply and demand in the market for rights. A fisherman will obviously find it advantageous to retain his existing holdings of rights only if, $(\partial R_i(L_i, X)/\partial L_i) = (\partial R_i(H_i, X)/\partial H_i) \geq m$; (where H_i denotes the current level of harvest); otherwise he will become a seller. No fisherman will want to retain rights in excess of his catch level, so long as they command a positive price, and he is prohibited from catching in excess of his holding rights. Hence $H_i = L_i$, where L_i denotes the quantity of rights held.

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[10] Indeed, an arrangement that has some of the characteristics of the system suggested here is reported to be emerging from the cooperative action of herring fishermen, who operate under restrictive licensing, in the Bay of Fundy. A governmental system of individual fishermen's quotas is currently being considered for Canada's west coast abalone fishery.

Thus, given a total available catch $L = \sum L_i$, and the behavioral condition above, namely that a fisherman will buy rights if $(\partial R_i(L_i, X)/\partial L_i) = (\partial R_i(H_i, X)/\partial H_i) > m$ and sell rights if $(\partial R_i(L_i, X)/\partial L_i) = (\partial R_i(Hi, X)/\partial H_i) < m$, the market will arrive at some equilibrium price m^* and distribution of rights $L^* = (L_1{}^*, L_2{}^*, \ldots, L_n{}^*)$, (assuming that at least one solution exists). An important feature of this equilibrium is that it maximizes $\sum^n{}_{i=1} R_i(L_i)$, because the fishermen who can realize the highest marginal benefits from catch rights (i.e. $\partial R_i(L_i, X)/\partial L_i$) will bid rights away from these realizing lower marginal gains. Thus rights will tend to become distributed efficiently among enterprises that will be induced to adopt the most efficient methods available to be able to compete for rights. In equilibrium, all enterprises will be driven to the point of minimum long-run average costs associated with the least-cost technology applicable to the fishery, since this condition allows them to meet the highest possible price for rights consistent with nonnegative profits. Thus we argue that a quantitative rights scheme leads not only to full capitalization of potential resource rents in the value of the rights, but also to technical efficiency and progressiveness in the fishery. It is also clear that such a scheme leaves no incentive for fishermen to engage in strategic behavior, or other wasteful use of inputs, because the associated higher costs would render him unable to compete for rights.

OPTIMAL STOCK MANAGEMENT

It can also be shown that the characteristics of the rights scheme described here satisfy the conditions for a social optimum which are derived using the standard dynamic fisheries model. We adopt the usual population equation (Clark and Munro 1975):

$$\dot{X} = F(X) - \sum_{i=1}^{n} H_i \tag{1}$$

where $F(X)$ is the natural growth rate of the stock and into which we can substitute L_i for H_i, as above. Given the traditional Scott–Gordon objective of maximizing sustainable economic rent (Gordon 1954), the optimal solution is found by maximizing $\sum^n{}_{i=1} R_i(L_i, X)$ subject to the constraint that $\sum^n{}_{i=1} L_i = F(X)$ (since $X = 0$ in equilibrium). This is a simple static optimization problem that can be solved by the method of Lagrange:

$$\max_{L_i, X, \lambda} V = \sum_{i=1}^{n} R_i(L_i, X) + \lambda(F(X) - \sum_{i=1}^{n} L_i). \tag{2}$$

The first order conditions for a maximum yield the following characterizations of the solution:

$$\frac{\partial R_i}{\partial L_i} = \lambda \quad (i = 1, 2, \ldots, n) \tag{3}$$

$$\sum_{i=1}^{n} \frac{\partial R_i}{\partial x} = -\lambda F'(X) \tag{4}$$

$$\sum_{i=1}^{n} L_i = F(X). \tag{5}$$

Given the usual interpretation of the Lagrange multiplier λ as the shadow price of a right, and if the industry is provided with a total quantity of rights equal to $F(X)$, clearly the existence of a market for rights results in efficient operation of the fishery. An important feature of this result is that the method and pattern of initial distribution of rights does not affect the resulting efficiency; that affects only the distribution of rent.

Adopting, alternatively, the more recently favored objective of maximizing the present value of rents accruing to the resource (see, for example, Clark and Munro 1975) the problem may be cast in the following terms (assuming catch rights are perpetual in tenure):

$$\max J = \int_0^\infty e^{-rt} \sum_{i=1}^{n} R_i(L_i, X)dt \tag{6}$$

subject to

$$\dot{X} = F(X) - \sum_{i=1}^{n} L_i. \tag{7}$$

Pontryagin's Maximum Principle (see Clark 1976) may be used to derive an optimal equilibrium solution given by

$$\frac{\partial R_i}{\partial L_i} = \lambda e^{-rt} \tag{8}$$

$$\sum_{i=1}^{n} \frac{\partial R_i}{\partial L_i} = \lambda e^{-rt}(r - F'(X)) \tag{9}$$

$$\sum_{i=1}^{n} L_i = F(X). \tag{10}$$

In this case the market will value a right according to the present value of the entire stream of rents accruing to it over time. Thus the market sets $m = \lambda e^{-rt}$, the shadow price of a right, and the efficiency of this system is once again clear.

The regulatory authority is thus faced with the task of estimating the stock size X, and must have information about the revenue functions $R_i(H_i, X)$ to solve for the optimum stock size X^*, and optimal catch $F(X^*)$. This requirement exists for any rational management policy however, and although a drawback to all of them, it should not figure in comparisons of alternative policies. The advantage of the rights scheme is that no extra calculations are necessary since the authority simply needs to issue the number of rights required to adjust the stock to any desired level, or to maintain the stock at a given level, and that catch will be taken efficiently. Thus use of the rights scheme enables the authority to completely separate the problems of efficiency, and distribution of rent, and in particular does not impose any given distribution on the efficient solution.

Finally, a word of caution is in order against a casual interpretation of the results described here as being identical with those that would obtain under a catch royalty system. As explained in the main text, fishermen who compete for the available catch under the rule of capture have strong incentives to adopt technologies and strategic behavior, and these interfere with their individual ability to accurately estimate the increase in catch they can realize from a marginal increment of fishing effort. Thus, since there is no commonly held deterministic relationship between harvest and effort, the harvest function cannot simply be inverted to yield a net revenue function, and the simple analysis used here does not apply.

In summary, we have shown that a competitive market for quantitatively specified rights to fish will lead to a socially optimal organization of the fishery insofar as the prescribed catch will be taken at least cost, potential rents will be fully realized, and none of the incentives that generate excess capacity and distorted technology under traditional fishing regimes will emerge.

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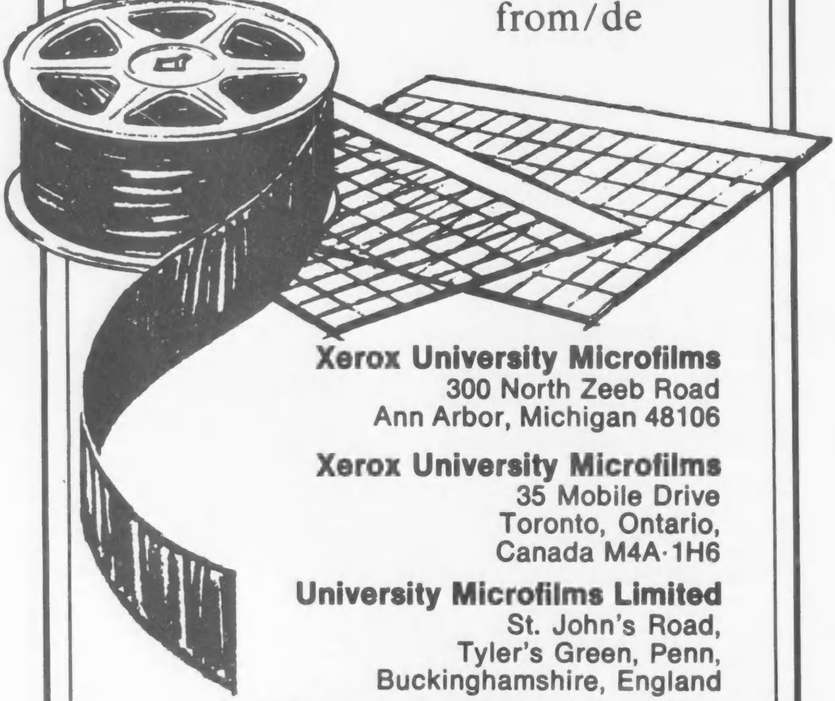

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